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ABSTRACT

Thirty-six lesson plans for the first of a four-year electrical apprentice technical training program are presented in this instructor's manual. Also included are student worksheets and information sheets for each lesson, and copies of unit tests. (Answers to the worksheets and tests are provided.) The lesson plans are generally organized into four steps: introducing the lesson, presenting the lesson (e.g., demonstration), student application (use of worksheets), and checking and follow-up (checking answers to worksheets). Some of the lesson topics are tools and equipment, introduction to electricity, electromotive force, combination currents, voltage drop, cable assemblies, electrical metallic tubing, cabinets and cutout boxes, fluorescent lighting, and blueprint reading. (Student worksheets and information sheets are also available separately--CE 018 354. Other related documents, CE 018 350-360, include a basic mathematics review, jobsite supervisor's manual, and instructor's manuals and worksheets for the other three years of the program.) (JH)

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ED160878

INSTRUCTOR'S MANUAL
FOR
ELECTRICAL APPRENTICE
TECHNICAL TRAINING

SERIES NO. A
(First Year)

Revised to meet 1978 Electrical Code

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND THE ERIC SYSTEM CONTRACTORS."

CE 018 353

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

An Equal Rights Note: Wherever, in this manual "man," "men" or their related pronouns may appear, either as words or as parts of words (and other than with obvious reference to named male individuals), they have been used for literary purposes and are meant in their generic sense (i.e., to include all humankind-both female and male sexes).

FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which he performs duties specifically assigned to enhance his learning in his field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help him to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.

Roger G. Worthington

Roger G. Worthington, Director
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Department of Community Colleges

PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with his training. It will also enable the apprentice to know what skills and knowledges will be required of him. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer, diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before he attempts to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964, by:

W.F. Humbert, III, Electrical Engineer
Winston-Salem, North Carolina

The Instructor's Manuals, Information and Orientation Sheets were developed by:

Howard E. Hedinger, Educational Consultant
Department of Community Colleges
Raleigh, North Carolina

The manual was revised in 1967, 1971, and 1975.

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* Not included - order separately.

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ASSIGNMENT REFERENCES

ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
Your Future in the Electrical Industry	A-1	*Note # 1 *Note # 9	*Note # 4	*Note # 2	*Note # 3	*Note # 9 *Note # 8
Your Apprenticeship	A-2					*Note # 8
Employee, Employer, & Customer Relations	A-3					*Note # 8
Tools & Equipment	A-4					*Note # 5
Construction Materials	A-5					*Note # 6
Safety & First Aid	A-6					*Note # 7
Introduction to Electricity	A-7	1 thru 3	1-101 1-1 thru 1-41		1-21 thru 1-29	Basic Math Pg. 1-6
Ohm's Law	A-8	23 thru 27 23 thru 27	1-123 2-24 thru 2-41		1-104 thru 1-109	Basic Math Pg. 23-28
Current	A-9	4, 5, 7,	1-40 thru 1-50		1-31 thru 1-37	Basic M. Pg. 4

*Note # 1: Page Numbers Listed
*Note # 2: Article Numbers Listed
*Note # 3: Division and Section Numbers Listed
*Note # 4: Chapter and Page Numbers Listed
*Note # 5: Trip to Contractor's Shop to See Tools
*Note # 6: Trip to Contractor's Shop to Visit Warehouse
*Note # 7: Safety and First-Aid Specialists--Visitor, Lecture and Demonstration
*Note # 8: See Orientation for Reference List
*Note # 9: Basic Math References in left column are 2nd edition; Basic Math References in last column are 3rd edition (1972).

ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
Resistance	A-10	1-8 274 thru 329	1-98 thru 108 2-24 thru 41		1-38 thru 1-42 1-90 thru 1-102	Basic Math Pg. 5-6
Electromotive Force	A-11	3, 7 180	1-83 thru 87 1-19 thru 1-40		1-29, 30, 51, 70 thru 82	Basic Math Pg. 4
Power and Work	A-12	389-406 192 thru 222	2-42 thru 54		1-56 thru 1-69 1-110 thru 1-111	Basic Math Pg. 199-222 Pg. 649-663
Series Circuits	A-13	68 thru 112	2-7 thru 23		3-1	Basic Math Pg. 68-111
Parallel Circuits	A-14	113 thru 159	2-55 thru 89		3-2 thru 3-4	Basic Math Pg. 113-158
Combination Circuits	A-15	159 thru 191	90 2 thru 102		3-5 thru 3-9	Basic Math Pg. 160-165
Wire Construction	A-16			310	2-1 thru 2-23	Basic Math 445-455,428
Wire Insulation	A-17	337 thru 340	5-74	310	2-24 thru 2-221	
Voltage Drop	A-18	427 thru 456 342 thru 347		210, 215	3-56 thru 3-76	Basic Math Pg. 23, 449-454
Introduction to the Nat'l Elect. Code	A-19			No 90, 100, 110	9-1	
General Requirements for Wiring Installations	A-20		5-74	310, 400, 380, 370, 300, 250, 424, 374	9-293 thru 9-311	
Single Conductor Wiring	A-21			320, 324	9-9, 9-13, 9-16, 4-89 thru 4-95	
Cable Assemblies	A-22			333, 334, 336, 338, 339, 337, 363, 340	9-76 thru 9-79 9-87 thru 9-89	

ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
Metallic Sheathed Cables	A-23			330, 333, 334	9-57 thru 9-60 9-80 thru 9-87	
Special Cords and Wires	A-24			400, 402	2-73 thru 2-76 2-126	
Rigid Metal Conduit*	A-25			345 346, 300	9-56 thru 9-115	
Electrical Metallic Tubing	A-26			348 300	9-183 thru 9-193	
Rigid Nonmetallic Conduit & Flexible Metal Conduit	A-27			300, 347, 350, 351 349	9-116 thru 9-147	
Outlets, Switch & Junction Boxes & Fittings	A-28			370	4-104, 9-81, 9-186, 9-226 9-315, 9-322	
Auxiliary Gutters & Wireways	A-29			374, 362	9-326, 9-22, 9-240	
Cabinets & Cutout Boxes	A-30			373	9-325	
Storage Batteries	A-31		1-23 thru 1-29	480 668	4-140 thru 4-232	Basic Math Pg. 4
Fuses & Overcurrent Protective Devices	A-32		2-47 thru 2-48	240	4-39 thru 4-74	Basic Math Pg. 8, 10
Lighting Fundamentals	A-33			410	10-1 thru 10-102	Manufactory Design & Layout Handbook
Fluorescent Lighting	A-34			410	10-103 thru 10-137	Manufactory Design & LayoutHandbook
High-Intensity Discharge Lighting	A-35			410	10-138 thru 10-184	Manufactory Design & Layout Handbook
Blueprint Reading	A-36			90		

*& Intermediate Metal Conduit

ELECTRICAL APPRENTICE TECHNICAL TRAINING
(GUIDELINES)

TO THE INSTRUCTOR:

- It is suggested that the instructor use an Orientation Sheet to help him to become acquainted with the apprentice. Name, address, birthplace, education, employers, and type of work, sponsoring employer, home situation (marital status and number of children), hobbies, likes and dislikes, etc., should be included.

- The Instructor's Manual and the Assignment or Worksheets have been revised to update the materials. Lessons are arranged in topics to reflect electrical installation rather than to stress electronics.

- The brief Lesson Plans should act as a guide in conducting classes and in organizing your program. It is recommended that you write out your own plans, using illustrations that are familiar and timely.

- The Information and Worksheets are designed to help the apprentice to master the related technical materials found in textbooks and references. The answer sheets are included in the Instructor's Manual.

- The Orientation pertaining to the details of the Apprenticeship Program and the requirements of the Related Instruction should be presented at the beginning of the first-year course.

- MATHEMATICS PRETEST AND BASIC MATHEMATICS REVIEW

  The 1978 Revision Committee recommends that the following procedure be followed:

  1. The session following Orientation Topics can be used to administer Mathematics Pretest, (Sections I thru III) with 43 questions concerning basic fundamental arithmetic. (See Reference Sheet for ordering the test or use the original Electrical Series A, Test 1.)

  2. The individuals that complete the Pretest satisfactorily may work on advanced applied mathematics, such as slide rule practice or other topics.

     For the individuals that need to spend time in reviewing fractions, decimals, etc., a separate manual called Basic Mathematics Review has been prepared for this purpose and should be ordered with all Series A, First-Year Worksheets.

3. The students assigned to the Math Review are expected to *work on their own time* or attend the Learning Lab for additional help. The instructor should check the work and assist the students during the application or study part of the regular sessions. Answer sheets are supplied in the Appendix of the Instructor's Manual.

4. The Basic Mathematics Examination will be furnished for you to administer after the lessons have been completed.

- The Apprentice Trainee is required to spend a minimum of 144 hours per calendar year in a Related Training Program whether in a school situation or by correspondence.

- The instructor should take time to review the entire course to understand the relationship of the materials. Also, this will help in planning so that the lessons will be completed in 144 hours.

- In the event the instructor uses individualized self-pacing methods where the students work at their own pace, he may need more programmed materials. Consult the Learning Lab for help in such a case.

- *Assignments* and *page references* have been placed on a sheet following the Table of Contents. This sheet can be revised easier than all the lesson sheets when textbooks are changed. It is suggested that the references be written on the chalkboard for each assignment.

- Each apprentice or student should have a large three-ring notebook to keep the lesson sheets, assignments, and notes.

- Answer sheets for both the *Worksheets* and the *Tests* have been placed in the Instructor's Manual for your use.

- *Corrections* for the Worksheets will be attached or listed in the Instructor's Manual. Please call attention to errors in printing when you make the assignment.

- THE FOUR-STEP OUTLINE

Each lesson plan is outlined into the "four-step" method of instruction and should assist you in presenting the lessons. In group instruction, it is recommended that the class period include the following:

Step I - INTRODUCING THE LESSON:
Call attention to interesting facts concerning the subject.

Step II - PRESENTING THE LESSON:
Demonstrate the use of necessary tools, materials, problems, and experiments. A well-presented lesson will require the student to do a minimum of reading in the assigned texts.
NOTE: When adequate equipment is provided, each student can perform the experiments individually. Show films or slides related to the subject. Discuss problems encountered on the job.

Step III - APPLICATION:
Make use of the assignment sheets prepared for each lesson. The assignments serve not only as a valuable aid to the learner, but also indicate to the instructor how well the lesson was taught.

Step IV - CHECKING AND FOLLOW-UP:
Check the worksheets with aid of answer sheets. This can be done quickly by the instructor or by exchange of papers in class. Return the papers to the students to correct mistakes and give individual help to those that need it. Call attention to common errors and discuss the problems or questions that were incorrect.

- TESTING PROCEDURES:

1. Short tests can be given each week on the lesson or the previous assignment.

2. A thorough test should be given shortly after completing a unit or group of lessons. This test should cover six weeks work or less.

3. A good comprehensive test administered at the end of the course will act as a gage of progress for the year. Some questions using charts, tables, and National Electrical Code can be of the "open-book" type.

4. All tests should be checked in detail, reviewed in class and returned to you. Tests should be retained by you and the committee as a part of the student's record.

- Please note that the assignment references for textbooks list the the page numbers.

The National Electrical Code references are "Articles."

The American Electrician's Handbook lists the Division and Section; these are not the page numbers.

- TEXTBOOKS:

  NOTE: Book stores at the institutions can order the textbooks and receive the school discount.

1. Basic Mathematics for Electricity and Electronics by Singer; 3rd Edition, 1972; $10.50; McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N.Y. 10036

2. Basic Electricity by Van Valkenburgh, Nooger, and Neville; 1st Edition, 1954; #0033 5 volumes paperback - $3.50 each; #0039 1 volume cloth - $16.50 less discount; Haden Book Company, Inc., 116 West 14th Street, New York, N.Y. 10011.

3. American Electrician's Handbook by Croft, Carr, and Watt; 10th Edition, 1972; $26.00; McGraw-Hill Book Comapny, Inc., 330 West 42nd Street, New York, N.Y. 10036.

4. National Electrical Code, Latest Edition; Approximately $6.25; National Electrical Contractors Association, 700 O.F.C. Building 1730 Rhode Island Avenue, N.W., Washington, D.C. 20036.

5. Steel Electrical Raceways Design Manual; Approximately $2.00; American Iron & Steel Institute, 150 E. 42nd St., New York, N.Y. 10017.

- INSTRUCTIONAL MATERIALS:

  The necessary materials should be ordered from the Department of Community Colleges, Program Development Section, Raleigh, N.C. 27611

  1. Instructor's Manual - First Year - Series A
  2. Student Information and Worksheets - First Year - Series A
  3. Mathematics Pretest
  4. Basic Mathematics Review
  5. MAT 1111 - Slide Rule
  6. Unit Tests (Series A) Copy of tests without answers is included in Instructor's Manual; please have your own student tests printed.

YOUR FUTURE IN THE ELECTRICAL INDUSTRY

DESIRED RESULTS:

1. To attain a better understanding of the Apprenticeship Agreement.
2. To reveal the many opportunities that exist in the electrical industry.
3. To attain a thorough understanding of the objectives and operation of the related instructional program.

PRESENTING THE LESSON:

1. Explain and discuss the Apprenticeship Agreement.
2. Show the apprentice the many opportunities in the electrical industry.
3. Give them some advantages and disadvantages or hazards of the trade.
4. Explain the related instructional benefits in detail, especially in relation to electricity.
5. Briefly outline the course and how to use it.
6. Explain how the "Basic Mathematics Review" will be handled.
7. Call to the attention of the apprentices the "Tips on How to Study." They should read and reread this material.

APPLICATION:

Ask the class to read the material again on "Your Future in the Electrical Industry."

CHECKING AND FOLLOW-UP:

Discuss any questions that individuals may ask concerning the apprenticeship and the electrical industry.

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YOUR APPRENTICESHIP

DESIRED RESULTS:

1. To understand the role of the local committee and the EMPLOYER in apprenticeship training.
2. To study all facets of apprenticeship training and how the program operates during the four years of service.

PRESENTING THE TOPIC:

1. Give the apprentices a general review of what is expected of them during the four years of indenture. Discuss the Standards of Apprenticeship.
2. Discuss the role of the local committee. In some places an interested committee member may be asked to meet with the class.
3. Discuss the role of the EMPLOYER and how he looks to apprentices for future foremen.
4. Sell them on the idea that apprenticeship will lead to a life's work worth the effort they put into it.
5. Discuss the importance of RELATED TRAINING to the apprentice.

APPLICATION:

Give the students time to complete the answers for the lesson.

CHECKING AND FOLLOW-UP:

Ask individual students to read the answers to questions. Then discuss each question and decide upon the best responses.

EMPLOYEE, EMPLOYER, AND CUSTOMER RELATIONS

DESIRED RESULTS:

1. To aid the apprentice in becoming a well-rounded employee.
2. To give the apprentice an insight into the general organization, plan, and function of an average contracting firm.
3. To show the importance of the local apprentice agreement.
4. To stress that the apprentice represents the company in the eyes of the customer.

INTRODUCTION:

Many employees have no knowledge of the problems which must be solved by employers. In many cases, misunderstandings will be prevented and better employer-employee relations will result when an employee understands some of the problems. Where action of an employee can assist the contractor in operating his business profitably, it enables the contractor to make money and be able to stay in business and provide work for his employees. The apprentice must sell his firm and his services to his customers.

PRESENTING THE LESSON:

The instructor should use the Information Sheets prepared for this lesson and stress all the ideas presented to the apprentice. Bring in other ideas that may be presented in the lesson that affect employee-employer relations. How should the apprentice care for the company's tools and transportation equipment? What are the types of organizations and how do they operate? How do human relations and salesmanship apply to the work of the apprentice?

APPLICATION:

The apprentices should study the Information Sheets and answer the questions listed which will be discussed in a class session.

NAME______________________________ ORIENTATION

DATE______________________________ A-3

EMPLOYEE, EMPLOYER, AND CUSTOMER RELATIONS

The apprentice has the right to expect his employer to see that he is taught the skills of the trade under the careful supervision of competent workmen and knowledgeable instructors. He should expect to receive well-rounded experience in as many phases of electrical work as possible. The employer, on the other hand, has the right to demand that the apprentice protect his property and interests. The employer should be interested in the progress of his apprentices as they should be in the progress of the company for which they work. Both the employer and the employee should strive toward the best possible relationship. The apprentice should realize that the orders or instructions of his immediate superior or his employer are based on conditions existing in the business world and are not necessarily personal.

A contracting company may be compared to a wheel in which the office represents the hub, the men in the field represent the spokes, and the customers represent the rim. No one part can get along without the other. The owner, himself, may well have started out in the industry as an apprentice or he may have never actually worked with the tools. He is, in any event, a busy man and cannot personally supervise all phases of his company and must have qualified men to do so for him. The contractor is dependent for his success to a large degree on the ability of the employees under his direction. The success of the men on the job, on the other hand, depends considerably on management. You can readily see that the greater the employee-employer relations, the greater is the chance of success for all concerned.

Every employee expects fair wages for a fair day's work and his employer expects the opposite. A fair day's work is a matter of agreement between the two. The length of the workday, fair wages, and many other matters of concern to the employee are determined by the company policy. Every man should be familiar with these policies so that he may know exactly what he can and cannot expect as an employee of the firm for which he works.

It is the customer or client who indirectly pays the wages of the employee. Under many conditions the electrician is the only direct contact between his employer and the customer, and the customer judges the electrical company by the conduct and skill of its representative. The electrician is charged with the responsibility of protecting and improving both his own reputation and that of his employer This can be accomplished by working efficiently, creating the least inconvenience and being honest and tactful in dealing with the customer.

The business world revolves on salesmanship. Just as you had to sell yourself to your employer in order to become an apprentice, he must sell his firm and his services to his customers. In the future, you will be called upon to sell yourself and your skills. The better the product, the easier the job of selling. What should be considered in improving you--the product? Character and personality must receive as much attention as improving one's skills. More persons are discharged from their jobs because of personal factors that for lack of ability. Honesty heads the list in obtaining a good reputation. Once a man loses his integrity, the path to future advancement or success is almost surely lost also. In selling yourself, a long list of personality traits make the job easier. Some of these include sincerity, thoughtfulness, generosity, modesty, unselfishness, and friendliness. It goes without saying that personal appearance (how the product looks to the buyer) also plays an important part in salesmanship.

Many employees believe they will be rewarded and promoted by simply working for a specified period of time. The employer, however, looks for more than routine performance of work. He looks for the man who considers himself as part of the overall team, the man who understands his job in relationship to the company and who is as concerned for the success of his firm as himself.

Questions for Discussion

1. What are the responsibilities of the employee to his employer?

2. What are the responsibilities of the employer to his employee?

3. Why are customer relations important to the employee of an electrical contractor?

4. Why is personal appearance important to one working in the electrical trade?

5. How can an apprentice affect the image of the company he works for?

6. Why is a good reputation important to an electrician?

7. Why is a good reputation important to a contractor?

8. List the personality traits you like to see in the men you work with.

9. What is the difference in the method of payment of office personnel and craftsmen in the field?

10. How can an apprentice help in determining the actual cost of a job?

11. List as many items as you can think of that are covered by company policy.

12. How do wages affect the company's ability to sell a job?

TOOLS AND EQUIPMENT

DESIRED RESULTS:

1. To learn the names, uses, and care of the basic tools used on the job.
2. To stimulate the students' interest in the use of catalogs to learn the names of tools.

MATERIALS AND REFERENCES:

1. Tool kit of hand tools used in the trade.
2. Catalogs of electrical tools from local supply houses.

INTRODUCTION:

The lesson materials are used primarily to introduce the basic tools of the trade for material handling, fabrication and assembly, and installation.

PRESENTING THE LESSON:

The value of this lesson lies in the discussion of tools in class. Be sure to allow time to discuss the proper use and care of tools. Warn the apprentice to respect the tools of others, especially those furnished by the contractor.

APPLICATION:

Using the assignment sheets, the students will fill in the common names of tools used by apprentices and journeymen.

CHECKING AND FOLLOW-UP:

Check the assignment sheets and return to the apprentice to place in his workbook for future reference.

NAME________________________ LESSON NO. A-4

DATE________________________ WORKSHEET A-4

TOOLS AND EQUIPMENT

1. What six hand tools should a beginning apprentice have?

(a)____________________
(b)____________________
(c)____________________
(d)____________________
(e)____________________
(f)____________________

2. An advanced apprentice should have added the following tools:

(a)____________________
(b)____________________
(c)____________________
(d)____________________
(e)____________________
(f)____________________
(g)____________________
(h)____________________
(i)____________________
(j)____________________

3. A journeyman electrician should have added these tools:

(a)____________________
(b)____________________
(c)____________________
(d)____________________
(e)____________________
(f)____________________
(g)____________________
(h)____________________

4. An electrician can often be judged by the type and condition of the tools he carries. True/False. __TRUE__

5. Good tools enable the electrician to perform his work more efficiently and in a more workmanlike manner. True/False. __TRUE__

6. Listed below are some of the more familiar heavy tools which the contractor generally supplies. In the blanks provided, match the letters a, b, or c of the tool classifications which may apply to each item:

   a. Material handling
   b. Fabrication and assembly
   c. Installation

_____Scaffolds
_____Work benches
_____Trailers and carts
_____Vacuum-blower units
_____Gang boxes
_____Ladders
_____Cranes and bucket trucks
_____Cable pulling machines
_____Trucks
_____Trenchers and back-hoes
_____Walkie-talkie radios
_____Fork-lift trucks
_____Portable generators
_____Conduit and EMT benders
_____Power drills
_____Chain hoists
_____Hydraulic knock-out sets
_____Portable power hack saws
_____Concrete saws
_____Hydraulic compression tool
_____Electric rota-hammer

CONSTRUCTION MATERIALS

(Conduit and Cable Fittings)

DESIRED RESULTS:

1. To help the beginner to learn the names and uses of the more basic materials of the trade.
2. To use the electrical catalogs for specifications of materials and how to order them.

MATERIALS AND REFERENCES:

1. Samples of various materials; switches, boxes, connectors, clamps, conduit, wire, lighting equipment, etc.
2. Catalogs from various supply houses.
3. Electrical Conduit and Cable Fittings, Thomas and Betts.

INTRODUCTION:

The samples of various materials and the use of catalogs will introduce a general discussion of materials as used in your area. The bulletin, Electrical Conduit and Cable Fittings, will show the picture and use of fittings for raceways and cable. All materials must be electrically safe.

PRESENTING THE LESSON:

Best results will be achieved by introducing a general discussion of materials as used in your area. The common trade name for much of this material will vary from place to place, so be sure to supply the class with the common usage name for your area. Make use of the electrical catalogs and information sheets prepared for the lesson.

APPLICATION:

Using the information sheets, the student should study the classifications, sizes, and rating of equipment along with related items. Review the NEMA enclosure types and explanations for your information.

CHECKING AND FOLLOW-UP:

Hold a discussion-type class by reviewing the Information Sheets.

INFORMATION SHEET LESSON NO. A-5

CONSTRUCTION MATERIALS

1. Any item of material installed on any electrical job should:

   (a) Be electrically safe.
   (b) Have the necessary protective cover or housing.
   (c) Have the proper insulation.
   (d) Be suited for the installed environment.
   (e) Fit the space available.
   (f) Not conflict with other trades equipment.

2. Any electrical job is made up of a group of small items connected together. A big job is just a lot of small jobs.

3. These items can be grouped into the following classifications:

   (a) Conductors
   (b) Raceways
   (c) Devices and plates
   (d) Switches and over current protective devices
   (e) Switchboards and panelboards
   (f) Transformers
   (g) Lighting equipment
   (h) Electric heating
   (i) Motors and controllers
   (j) Capacitors and regulators
   (k) Power sources
   (l) High voltage equipment
   (m) Signal and communication systems

4. Sizes and ratings of equipment:

   (a) Wire - Gauge and ampacity and insulation, multi-conductor
   (b) Conduit - Inside diameter, steel, aluminum, EMT, plastic
   (c) Switches and circuit breakers - Voltage and ampacity, interrupting capacity
   (d) Devices - Voltage and ampacity
   (e) Switchboards and panelboards - Voltage, ampacity and frame size
   (f) Transformers - Voltage, ampacity, taps, insulation, ventilation
   (g) Lighting equipment - Incandescent, flourescent, high-intensity-discharge, voltage, auxillary equipment, lamps, hanging
   (h) Electric heating - Voltage, wattage, control equipment, baseboard, ceiling, duct, radiant panel, furnace
   (i) Capacitors and regulators - Voltage, output, degree of sensitivity, control
   (j) Power sources - Package unit or components, drive equipment, gas, diesel, oil, batteries, separate service, voltage, ampacity required, speed of change over

(k) High voltage equipment - Voltage, ampacity, shielding, terminations, cooling, isolating, conductors, switching
(l) Signal and communications - Type, use expected, coverage needed, capacity, interlocked with other systems, expansion, electrical or electronic

5. Related items of equipment:

(a) Wire - Terminations, lugs, tape, connectors, sealants
(b) Conduit - Straps, hangers, clips, racks, boxes, vireway, cable tray, bus duct, underfloor duct, cable duct
(c) Switches and circuit breakers - Special fuses, "Tri-Pack" units, thermal and/or magnetic trips, bolted pressure switches, enclosures
(d) Devices - Standard, special applications, twist-lock, split circuit, combination units, plates
(e) Switchboards and panelboards - Surface, flush, free standing - copper/aluminum bussing, protective devices, metering, spare/space, feed-in and feed-outs
(f) Transformers - liquid-filled or dry; single or three phase, taps, enclosure, ventilation, insulation rating
(g) Lighting equipment - Mounting - direct, recessed, suspended, bases, racks, fire-proofing
(h) Electric heating - Step fusing, mechanical coordination, controls
(i) Capacitors and regulators - critical load, separate service, batteries, generators, switching equipment - automatic
(j) Power sources - Foundations, racks, auxillary equipment, fuel storage
(k) High voltage equipment - Towers or underground work, ducts or direct burial, traffic flow interruptions
(l) Signal and communications - Separate raceways, installation and hookup, warranty and service

6. NEMA enclosure types:

ENCLOSURES	EXPLANATION
NEMA Type 1 - General Purpose	To prevent accidental contact with enclosed apparatus. Suitable for application indoors where not exposed to unusual service conditions.
NEMA Type 2 - Driptight	To prevent accidental contact, and in addition, to exclude falling moisture or dirt.
NEMA Type 3 - Weatherproof (Weather Resistant)	Protection against specified weather hazards. Suitable for use outdoors.
NEMA Type 3R - Raintight	Protects against entrance of water from a beating rain. Suitable for general outdoor application not requiring sleetproof.
NEMA Type 4 - Watertight	Designed to exclude water applied in form of hose stream. To protect against stream of water during cleaning operations, etc.
NEMA Type 5 - Dust Tight	Constructed so that dust will not enter the enclosed case. Being replaced in some equipment by NEMA 12 Types.
NEMA Type 6 - Submersible	Intended to permit enclosed apparatus to be operated successfully when submerged in water under specified pressure and time.
NEMA Type 7 - Hazardous Locations A, B, C or D Class I - Air Break Letter or letters following type number indicates particular groups of hazardous locations per N.E.C.	Designed to meet application requirements of National Electrical Code for Class I, Hazardous Locations (Explosive atmospheres). Circuit interruption occurs in air.
NEMA Type 9 - Hazardous Locations E, F or G Class II, Letter or letters following type number indicates particular groups of hazardous locations per N.E.C.	Designed to meet application requirements of National Electrical Code for Class II, Hazardous Locations (Combustible dusts, etc.)

SAFETY AND FIRST AID

DESIRED RESULTS:

1. To impress on the apprentice the need for him to practice SAFETY.
2. To keep the apprentice aware of the hazards of his job and to do all he can to improve SAFETY in the electrical construction work.
3. To present a film on FIRST AID or have a specialist in FIRST AID make a presentation with demonstrations.

MATERIALS AND EQUIPMENT:

1. Safety posters and slogans
2. 16mm film projector
3. Safety and first-aid films
4. Safety manuals
5. First-aid manuals

INTRODUCTION:

Emphasize to the students that two of the major hazards of a construction job are falling objects and falls of workmen. The practice of good housekeeping will help to eliminate many hazards that result in accidents.

There seems to be a tendency to skip safety as a subject that is not very important. However, if you can prevent a broken bone for yourself or a fellow workman through good housekeeping practices, it would be a very important accomplishment.

Great strides have been made in safety and safety education in the construction field in recent years. There is still a great deal of room for improvement. In the electrical construction work, we must constantly keep ourselves aware of the hazards of our job. Each worker must continue to improve safety in his job daily--first of all for his own benefit, as well as for the sake of his family, his fellow workmen, and his employer.

Point out that many construction electricians have not only been crippled but also have died because of unsafe practices on ladders. Point out any local accidents caused by unsafe use of ladders. Experience has proven that the most effective way to reduce accidents is to concentrate on one phase of the accident problem at a time.

If there are specific safety regulations in the local apprentice agreement, now is the time to discuss them in conjunction with this lesson.

PRESENTING THE LESSON:

The instructor should give illustrations to encourage the apprentice to develop clean personal and safety habits. To instill in him a sense of responsibility and goodwill for his employer and all concerned will prove of great value.

In this and future lessons, safe practices will be discussed on many topics such as: ladders, tools, scaffolds, eye protection, and others. Careful consideration and study of such items may eliminate an accident to you or a fellow workman.

A few suggested things to do to make this lesson more effective:

1. Make it a general discussion of SAFETY.
2. Have a good many SAFETY posters available to illustrate a particular point.
3. Have men suggest SAFETY slogans - record and discuss some.
4. Have men discuss SAFETY practices they have observed on the job.
5. Have men discuss unsafe conditions they have observed on the job.
6. Have the class discuss accidents or near accidents they have witnessed where ladders were involved. Using the ladders for demonstrations:
    a. Point out "unsafe conditions" in using ladders.
    b. Point out "unsafe acts" while using a ladder.

NOTE: 1. Show a safety film which will apply or have a specialist in first aid make demonstrations.
2. Suggested maximum time to spend on this lesson-- one hour.

APPLICATION:

Have the students answer the questions on the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers to the questions and return to the student for correction and placing in workbook.

SAFETY

SAFETY PRECAUTIONS

It is an accepted fact that electricity, if not handled properly, is extremely hazardous. This fact has attributed greatly to the progress that has been made in its control. Through cooperation of manufacturers of electric equipment, governmental bodies, insurance companies, and others, the National Electrical Safety Code has been developed. This Code has played an important part in accident-prevention work.

Frequently, construction electricians working with the comparatively low voltage used in house wiring do not have the same respect for it as they do for the high voltage used in delivering current to transformers. They fail to realize that the relationship between the voltage and the resistance of the material serving as ground is the determining factor and therefore danger is not determined solely by the voltage. It should be thoroughly understood that the 110 volt current used in lighting circuits is sufficient to kill under many ordinary situations in which the electricians will be working. If the material to which the worker is grounded has low resistance to the flow of electricity, the amperage will be high, resulting in severe electric shock. Electric shock ranges from mild discomfort to actual stoppage of heartbeat and breathing. Serious burns may also result.

The extent of the injury received from electric shock is controlled mainly by the amount of current, the path of the current through the body, and the duration of the shock. The physical condition of the victim may also have a bearing. This fact should never be interpreted to mean that a strong individual should take chances with electricity.

The frequency of the current and the type of current, direct or alternating, are also factors affecting the nature of shock. High frequency current tends to produce heat instead of shock. This is also the case with direct current. Shock hazards are less, but more severe burns can be expected from direct current accidents. Accident reports indicate minor electric shock has caused serious accidents. In these cases, involuntary contraction of the muscles has caused workmen to fall from ladders and scaffolds.

While accidents with electricity are frequently serious, there are fewer safety precautions to be considered than in many other industries. The following rules should be carefully observed by all workmen employed as construction electricians.

1. Assume a circuit is alive until tested and proved dead.

2. Test circuits with proper testing equipment. (110 volt test lamp placed across a 440 volt line will blow up)

3. Use safety equipment such as insulated tools, rubber mats, and rubber gloves.

4. Main switches should be locked open and a tag indicating workmen are working on some part of the circuit before work is started.

5. Before closing a circuit, check carefully to see that workmen are clear of the circuit.

6. Observe the rules of the National Electrical Safety Code.

7. If minor repair of a live circuit cannot be avoided, arrange to have a qualified helper present.

8. Make all parts of a job safe even though they are temporary.

Aside from the hazards of electric shock, the construction electrician is subject to accidents similar to those encountered by other workmen in the building trades, such as falling from ladders and scaffolds, accidents in manipulation of tools, etc.

Falling is a major cause of industrial accidents. Workmen should avoid improvised steps and ladders. Dependable ladder and scaffolding equipment is available and should be used. Ladders should be inspected frequently to see that rungs or steps are not overly worn, loose, broken, or missing. Rails that are badly split should be discarded. Antislip feet are desirable for both step and straight ladders. They should be of a type designed for the particular purpose. The design of step ladders is an important factor in stability. Frequently, improper placing of ladders results in their slipping, or the workman trying to reach too far and becoming overbalanced.

NAME ______________________________ LESSON NO. A-6

DATE ______________________________ WORKSHEET A-6

SAFETY

1. List some ways that safety habits are responsible for cash savings.
   a. To your company as the employer.

   b. To you as the employee.

2. List several pieces of wearing apparel classed as safety equipment generally furnished by the company.

   a. ______________________ c. ______________________

   b. ______________________

3. In the event you are disabled, how much would you collect per week from Workmen's Compensation? $__________

4. Recall an accident that happened to you in the home or on the job. What safety rule was broken?

5. Give five safety habits an electrician should practice.

   a. ______________________ d. ______________________

   b. ______________________ e. ______________________

   c. ______________________

6. Write your favorite safety slogan.

7. Name five hazards on any construction job.

   a. ______________________ d. ______________________

   b. ______________________ e. ______________________

   c. ______________________

8. List five "unsafe conditions" that may show up in the normal use of a ladder by an electrician.

a. ______________________________ d. ______________________________

b. ______________________________ e. ______________________________

c. ______________________________

9. List five "unsafe acts" that may happen on ladders.

a. ______________________________ d. ______________________________

b. ______________________________ e. ______________________________

c. ______________________________

10. Show how good housekeeping is very much a part of your job. How is good housekeeping a good indication of a safe worker?

INTRODUCTION TO ELECTRICITY

DESIRED RESULTS:

1. To introduce basic electricity by explaining the behavior of electrons.
2. To show supplementary evidence of the electron theory by use of a film.

INTRODUCTION:

Some of the mystery which has veiled the subject of electricity in the past has been removed. For many years, the natural laws and observed behavior of electricity were the only available sources of information for a study of this subject. The electron theory of matter, which has been certified by these natural laws, has led to a better understanding of the nature of electricity. The knowledge gained from this lesson will be the foundation upon which many later lessons will be developed.

PRESENTING THE LESSON:

It should be stressed that no one has ever seen an atom or an electron. There has been a large amount of research time devoted to the subject, and most of the evidence accumulated from this research supports the electron theory. The behavior of electrons and most atoms generally follows a definite pattern. For this reason, it is possible to predict mathematically the results of many experiments before they are performed. These predictable results have been sufficiently stable to make it feasible to label the study of electrons a science.

There are still many unpredictable results of experiments and research problems. After the discovery of the electron in 1897, scientists finally became convinced that all matter was composed of a positive mass having a definite number of electorns in orbit around this mass. The number of electrons determined the type of matter. This idea provided a very neat package. There was only one thing wrong with the theory--it was not exactly true.

There is now supporting eivdence to indicate that some atomic structures are composed of more than twenty components in addition to the originally known parts. Scientists believe there are still others not yet discovered.

Some restraint should be used in defining the electron and electricity. It appears that there is a close association between these two factors, but keep in mind that there still is not an accepted definition for electricity.

In using the sun and the orbiting planets as an analogy for the description of an atom, be very careful not to leave any erroneous impression. The planets orbit about the sun very nearly in the same place. The electrons may or may not follow this pattern. Some electrons are transients. Even though it may be possible, so far as we know there is no transient planet in our solar system.

It is suggested that the local film library be contacted for suitable film to supplement this lesson. If a film is available, it should be reviewed carefully before showing. Unless it closely parallels the lesson, it could cause some confusion rather than supplementing the lesson.

APPLICATION:

Students should complete work on the assignment sheets for this lesson. Allow time for them to discuss questions about electrical theory.

CHECKING AND FOLLOW-UP:

Check the worksheets and allow time for the class to find correct answers. Discuss the questions that need explanation.

INFORMATION SHEET — INTRODUCTION TO ELECTRICITY — LESSON NO. A-7

CONDUCTORS AND INSULATORS

Conductors of Electricity

Copper is used as the most common conductor of electricity. From the figures below you can see that it contains nearly as many free electrons per square inch as silver and is less expensive.

Copper contains about 1,600,000 billion billion free electrons per square inch. (In electrical mathematics, this number is written 16×10^{23} and means 1,600,000,000,000,000,000,000,000.) The following list of common conductors show that as the number of free electrons decreases, the ability to conduct electricity decreases. It is a fact that when equal voltage is applied, the better materials will conduct more electricity.

Material	Free Electrons Per Cubic Inch	Material	Free Electrons Per Cubic Inch
Silver	16.4×10^{23}	Nickel	3.5×10^{23}
Copper	16×10^{23}	German Silver	3.3×10^{23}
Aluminum	9×10^{23}	Nichrome	2.5×10^{23}
		Iron	2.2×10^{23}

Insulators of Electricity

The materials considered to be the best insulators contain very few free electrons compared with metal conductors. It should be remembered that there is no material known as a perfect electrical insulator. It is evident that some electrons will flow when the material is subjected to voltage. Thus, when only a few electrons will flow, the material can be considered to be a good insulator. The following is a list of insulating materials and the amount of free electrons they contain per cubic inch:

Hard rubber	3	Waxed mahogany	670,000
Paraffin	270	Plate glass	1,380,000
Clear mica	14		

NAME____________________ LESSON NO. A-7

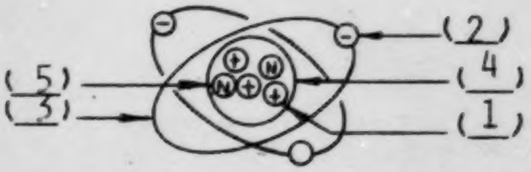
DATE____________________ WORKSHEET A-7

INTRODUCTION TO ELECTRICITY

1. Matter is anything which has weight and occupies SPACE.

2. The smallest particle of matter is an ATOM.

3. The atom:

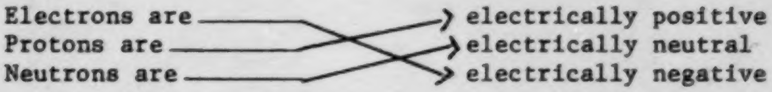


Match the number with the correct item in the above sketch.

1. Proton	3. Orbit	5. Neutron
2. Electron	4. Nucleus	

4. An atom is electrically neutral because it consists of equal number of positive charges called PROTON and negative charges called ELECTRONS.

5. Draw an arrow to the correct answer



Electrons are
Protons are
Neutrons are
electrically positive
electrically neutral
electrically negative

6. Electrical energy can be GENERATED by forcing electrons to move in certain paths.

7. Like charged particles will attract each other and unlike charged particles will repel each other. True/False FALSE

8. All electrons are alike regardless of the atoms of which they are a part. True/False TRUE

9. What is an insulator? Give two examples.

A MATERIAL THAT KEEPS ELECTRONS FROM FLOWING.

HARD RUBBER, CLEAR MICA

10. What is a conductor? Give two examples.

A MATERIAL THAT CARIES OR ALLOWS THE FREE FLOW OF ELECTRONS.

COPPER, ALUMINUM, NICKEL, GERMAN SILVER

OHM'S LAW

(Simple Circuits)

DESIRED RESULTS:

1. To understand the relationships of voltage, current, and resistance in an electric circuit.
2. To show how the formula may be used to determine the voltage, current, and the resistance of a circuit.

INTRODUCTION:

George S. Ohm, a German physicist, discovered that the amount of current that passes through a conductor depends upon the amount of pressure (voltage) and the resistance (ohms). Ohm's Law is expressed by the three forms of equations:

$$E = I \times R \qquad I = \frac{E}{R} \qquad R = \frac{E}{I}$$

Emphasize the fact that students who have trouble studying electrical subjects have failed to learn and apply Ohm's Law.

PRESENTING THE LESSON:

The relationship of amperes, ohms, and volts can be expressed by the formula $I = \frac{E}{R}$

(1) "I" stands for the intensity of the current flow in amperes.
(2) "E" stands for the electromotive force in volts.
(3) "R" stands for the resistance in ohms.

Show how Ohm's Law is so helpful in using what one learns about electricity, that the student should know how to use the formula in all its forms.

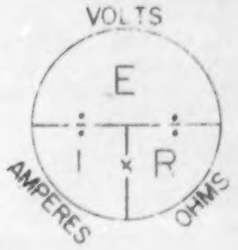
Adapt the formula to practical problems involving a house wiring circuit.

APPLICATION:

Have the students complete the assignment sheet.

CHECKING AND FOLLOW-UP:

Check assignment sheets and return to learner for correction and placing in workbook. Assign more problems from text for those that need more practice.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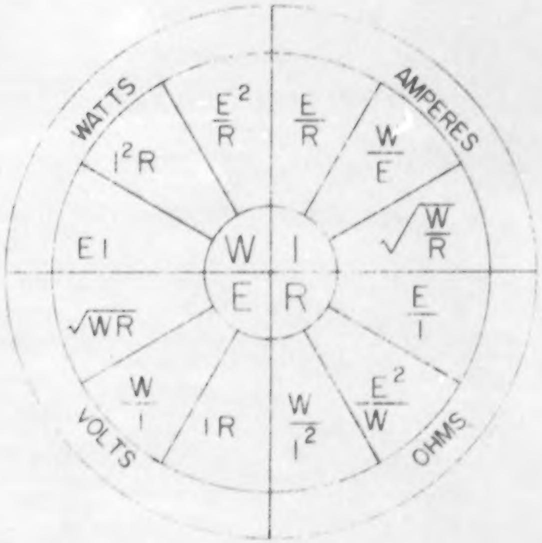
OHM'S LAW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$\sqrt{WR}$
$\frac{E}{I}$
$\frac{W}{I}$
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$\frac{W}{I^2}$
$\frac{E^2}{W}$

OHM'S LAW
(MODIFIED)

NAME________________________________ LESSON NO. A-8

DATE________________________________ WORKSHEET A-8

OHM'S LAW

1. List five applications for using Ohm's Law:

A. FINDING VOLTAGE REQUIRED TO PROVIDE A GIVEN CURRENT THRU ONLY A RESISTOR
B. FINDING CURRENT PRODUCED BY A GIVEN VOLTAGE IMPRESSED UPON ONLY A RESISTOR
C. FINDING VOLTAGE DROP CAUSED BY CURRENT PASSING THRU A RESISTOR
D. CALCULATIONS OF COMPLETE DC CIRCUITS WHICH DO NOT CONTAIN ANY EMF OTHER THAN THE IMPRESSED VOLTAGE
E. ANY CIRCUIT OR PORTION OF A CIRCUIT WHICH CONSISTS OF ONLY RESISTANCE

2. List three situations which Ohm's Law cannot be applied.

a. AC CIRCUITS IN GENERAL

b. COMPLETE MOTOR CIRCUITS

c. COMPLETE CIRCUITS CONTAINING AN EMF OTHER THAN IMPRESSED VOLTAGE

3. Express Ohm's Law for finding voltage. $E = I \times R$
VOLTAGE = CURRENT TIMES RESISTANCE

4. Express Ohm's Law for finding current. $I = \frac{E}{R}$
CURRENT = VOLTAGE DIVIDED BY RESISTANCE

5. Express Ohm's Law for finding resistance. $R = \frac{E}{I}$
RESISTANCE = VOLTAGE DIVIDED BY CURRENT

6. Match Column B to Column A.

(A)	(B)
1. EMF 3	1. Resistance
2. Current 4	2. Ohms
3. Opposes current flow 1	3. Electrical Pressure
4. Resistance measured in 2	4. Voltage ÷ Resistance
	5. Voltage ÷ Current

State the seven steps to be followed in solving problems using Ohm's Law:

a. READ THE PROBLEM CAREFULLY

b. DRAW A SIMPLE DIAGRAM OF THE CIRCUIT - RECORD GIVEN INFORMATION DIRECTLY ON THE DIAGRAM.

c. INDICATE THE VALUES TO BE FOUND BY QUESTION MARKS.

d. WRITE THE FORMULA

e. SUBSTITUTE THE GIVEN NUMBERS FOR THE LETTERS IN THE FORMULA. IF THE NUMBER FOR THE LETTER IS UNKNOWN, MERELY WRITE THE LETTER AGAIN. INCLUDE ALL MATHEMATICAL SIGNS.

f. DO THE INDICATED ARITHMETIC AT THE SIDE SO AS NOT TO INTERRUPT THE CONTINUED PROGRESS OF THE SOLUTION.

g. IN THE ANSWER, INDICATE THE LETTER, ITS NUMERICAL VALUE AND THE UNITS OF MEASUREMENT.

8. Solve the following:

a. Find the voltage to operate a light if it has 60 ohms resistance and draws 2 amperes.

$$E = I \times R$$
$$E = 2 \times 60$$
$$\underline{E = 120 \text{ VOLTS}}$$

b. Find resistance of a load if the voltage is 110 volts and draws 2.75 amperes.

$$R = \frac{E}{I} \qquad R = \frac{110}{2.75}$$

$$\underline{R = 40 \text{ OHMS}}$$

c. If a 15 ohm resistance is connected to a 60 volt generator What current would flow?

$$I = \frac{E}{R} \qquad I = \frac{60}{15}$$

$$\underline{I = 4 \text{ AMPERES}}$$

CURRENT

DESIRED RESULTS:

1. To inform the student of the nature of OHM'S Law and to show how this formula is used to determine the current of a circuit.
2. To understand that when electrons are put into motion, we have current flow.

INTRODUCTION:

The next three lessons will involve the three components of a circuit that make up Ohm's Law--namely, current, voltage, and resistance. Each component is studied individually and each lesson will point out the main points for the apprentice to learn and understand.

PRESENTING THE LESSON:

We have learned that all matter is composed of various particles, one of which is an electron. Now in this lesson when we put electrons in motion, there is current flow.

The main point of this lesson is to understand that current flow is the movement of electrons along the conductor. Current flow in a circuit changes as a result of resistance and voltage changes. The length, cross section, and different materials of a conductor will cause the current in a circuit to vary. Experiments show that when the voltage is decreased, the current flow is increased. The unit of measurement, symbol, and nomenclature used in conjunction with current are also pointed out.

Give an explanation and show the film, if available.

APPLICATION:

Have the students answer the questions on the assignment sheet. Give assistance where needed.

CHECKING AND FOLLOW-UP:

Check the papers and have the students correct the errors before placing them in the notebooks.

NAME________________________________ LESSON NO. A-9

DATE________________________________ WORKSHEET A-9

CURRENT

1. (a) An electric current is measured in AMPERES.

   (b) Give symbol for current. I.

2. True or False.

   (a) Current is the flow of electrons. TRUE.

   (b) The flow of an alternating current is reversed at regular intervals. TRUE.

   (c) A voltmeter measures current in units of amperes. FALSE.

   (d) The two general classes of electric currents are Direct and Alternating. TRUE.

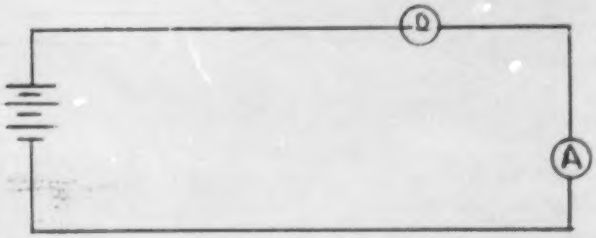
   (e) An ammeter is connected across the load or (parallel) in a circuit. FALSE.

   (f) One ampere is equal to a flow of 6 billion, billion electrons per second. TRUE.

   (g) A direct current always flows in the same direction. TRUE.

3. The flow of electrons is called an ELECTRIC CURRENT.

4. Draw a Sample Series Circuit Using a battery, lights, and ammeter. Show how to wire the ammeter in the circuit.



RESISTANCE

DESIRED RESULTS:

1. To understand that RESISTANCE opposes the flow of current in an electrical circuit.
2. To study the resistivity of the common conductors.
3. To learn the unit of measurement, symbol, and names used in conjunction with the term RESISTANCE.

INTRODUCTION:

Review the main points discussed about current and voltage. This lesson has one main point - resistance is an opposition offered to the flow of current in an electrical circuit.

PRESENTING THE LESSON:

Show by the use of Ohm's Law formula the relationship of RESISTANCE to current and voltage. The unit of measurement for resistance is the OHM, and the symbol for resistance is R. Adapt the formula $(I = \frac{E}{R})$ to find resistance. EXPLAIN how to change the formula to have $R = \frac{E}{I}$.

Use this formula to find the resistance in an electric circuit by substituting known values. Remember--to find the resistance in OHMS, one divides the E.M.F. in volts by the current in amperes.

Give an explanation and show the film, if available.

APPLICATION:

1. Answer questions concerning the film.
2. Have the students complete the questions on the assignment sheet.

CHECKING AND FOLLOW-UP:

Check the assignment sheets and allow time for the class to correct them. Discuss the questions found to be incorrect.

NAME ______________________ LESSON NO. A-10

DATE ______________________ WORKSHEET A-10

RESISTANCE

1. True or False

   (a) Resistance is measured in ohms and has a symbol I. FALSE .

   (b) Resistance opposes the flow of electricity. TRUE .

   (c) An ohmmeter is used to measure resistance in a circuit. TRUE .

   (d) There is no need to cut power off to check a circuit with an ohmmeter. FALSE .

   (e) Resistance causes heat to be produced by a current through it. TRUE .

2. List four factors affecting resistance of a conductor.

   (a) THE MATERIAL THE CONDUCTOR IS MADE OF.

   (b) THE DIMENSION (SIZE) OF THE CONDUCTOR.

   (c) THE TEMPERATURE.

   (d) THE LENGTH (1-102)

3. Choose one.

   (a) Conductors of (B) LOW resistivity are used for transmission lines and feeders. (a) high (b) low.

   (b) Conductors of (B) HIGH resistivity are used for incandescent lamps and toasters. (a) low (b) high.

4. What are the resistivities of the following conductors?

(a)	Copper	1.000
(b)	Aluminum	1.587
(c)	Silver	0.925
(d)	Tungsten	26.180

5. Which of the four mentioned above is the best conductor? SILVER .

6. The two wire gages used in this country are:

(a) AMERICAN WIRE GAGE (AWG)

(b) BROWN & SHARPE (B & S)

7. Express the following temperatures in degrees Fahrenheit:

(a) 0° C 32° F

(b) 22° C 71.6° F

(c) 90° C 194.0° F

(d) 100° C 212.0° F

8. Resistance (increases, decreases) with an increase in temperature. INCREASES

9. Loose connections on conductors will (increase, decrease) the resistance. INCREASE

10. A #10 aluminum wire (will, will not) carry the same current as a #10 copper wire. WILL NOT

11. The resistance of a copper conductor is 45 ohms at 65° F. What is the resistance at 194° F?

$$R_H = R_C + [\,\sigma \times R_C (T_H - T_C)\,]$$

$$= 45 + [\ .0022 \times 45\ (194 - 65)\ ]$$

$$= 56.65 \text{ OHMS @ } 194° \text{ F}$$

ELECTROMOTIVE FORCE

(Voltage)

DESIRED RESULTS:

1. To understand that voltage is the force or pressure that causes the electron to move.
2. To learn the unit of measurement, symbol, and names used in conjunction with voltage.

INTRODUCTION:

Review the difference between current and voltage and show their very close relation. Voltage is the second of the three important terms associated with Ohm's Law.

PRESENTING THE LESSON:

Voltage or electromotive force of an electric circuit is the pressure which causes the current to flow. It is measured in volts and is represented in the formula by the letter "E." Show from the references the individuality of the voltage, but at the same time its close relationship with the current.

The class should use time for additional study in the reference material.

Give explanation and show the film, if available.

APPLICATION:

Have the students to answer the questions on the assignment sheet.

CHECKING AND FOLLOW-UP:

Check the papers and have the students correct any incorrect answers. Discuss the questions that need explanation.

NAME ______________________ LESSON NO. A-11

DATE ______________________ WORKSHEET A-11

ELECTROMOTIVE FORCE

1. Can electricity be created or destroyed? Yes/No. NO .

2. List seven ways of producing an EMF.

   (a) ELECTROMAGNETIC INDUCTION
   (b) THERMAL ACTION
   (c) CHEMICAL ACTION
   (d) CHANGING ELECTRIC FIELDS
   (e) CONTACT BETWEEN UNLIKE SUBSTANCES
   (f) VIBRATION OF CRYSTALS
   (g) HEATING OF CRYSTALS

3. Choose one.

   (a) Electromotive force is measured in (C) VOLTS .
   (a) Amperes (b) Ohms [✓ (c) Volts]

   (b) The INCREASE of voltage will cause an increase in current.
   (a) increase (b) decrease

   (c) The symbol for voltage is (A) E .
   [✓ (a) E] (b) I (c) R

   (d) The instrument used to measure voltage is (C) VOLTMETER .
   (a) Ammeter (b) Ohmmeter [✓ (c) Voltmeter]

4. How should a voltmeter be connected in the circuit? IN PARALLEL WITH THE LOAD. .

5. Define voltage drop. THE DIFFERENCE IN PRESSURE BETWEEN TWO POINTS IN A CIRCUIT CAUSED BY THE RESISTANCE OPPOSING THE FLOW OF CURRENT.

6. What causes electrons to move once a switch is closed in an electrical circuit? VOLTAGE OR E.M.F. .

7. Define potential difference. THE DIFFERENCE IN PRESSURE, VOLTAGE, OR E.M.F. THAT FORCES THE CURRENT THRU A CIRCUIT. .

POWER AND WORK

DESIRED RESULTS:

1. To acquaint the student with some of the terms of electrical energy that apply to work and power.
2. To inform the learner that work is done when force accomplishes something (weight x distance). Power is the work done times the speed of doing it.
3. To solve problems involving the power formula.

MATERIALS, EQUIPMENT AND SUPPLIES:

1. Chalkboard
2. Lamp banks and meters

INTRODUCTION:

This lesson will introduce the students to the use of terms such as horsepower, watts, etc. Ask the students to check the labels on electrical equipment they see on the job for horsepower, watts, KW, voltage, and current rating. An electrician may be called upon to install a unit of equipment rated in horsepower, or watts, or voltage only. The electrician must decide how much current the piece of equipment will demand. Knowing the current needed, he must install the proper size wire and protect the circuit and equipment with the proper fuse. The power equations studied in this lesson will be used many times to find information not given on the name plate of electrical equipment.

PRESENTING THE LESSON:

For a practical demonstration of this lesson, use a lamp bank with lamps of various sizes. The ammeter and voltmeter will show a good relationship between the wattage of rating of the lamps, the applied voltage, and the current drawn by the circuit.

A thorough understanding and the ability to use the power equations should be stressed. Point out to the students the close relationship between the following power equation and the Ohm's Law equation.

$$P = IE \qquad E = \frac{P}{I} \qquad I = \frac{P}{E}$$

If more practice problems are necessary than given on the assignment sheet, see Basic Mathematics by Singer.

APPLICATION:

Have the students answer the questions and work the problems on the assignment sheet. Give assistance if needed, but do not give the answer.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against the answer sheet and return to the students for correction and filing in their notebooks.

NAME________________________________ LESSON NO. A-12

DATE________________________________ WORKSHEET A-12

POWER AND WORK

1. The capacity of doing work is ENERGY.
2. The time rate of doing work is POWER.
3. Mechanical power depends upon work and speed. The unit of measurement of mechanical power is FOOT POUNDS PER SECOND OR HORSEPOWER.
4. Electrical power is the product of current and voltage. The unit of measurement of electrical power is the WATT.
5. A horsepower is a unit of mechanical power. It is equal to 33,000 foot pounds per minute.
6. The electrical work done in one hour by one watt is a WATT HOUR.
7. A kilowatt equals 1,000 watts.
8. One WATT of electrical power is used when one volt causes one ampere of current to flow in a circuit.
9. One horsepower equals 746 watts (750 for calculations).
10. The energy or power supplied to the machine is called INPUT.
11. The useful energy or power delivered by the machine is called OUTPUT.
12. Efficiency is the ratio of output to input. Efficiency = $\frac{\text{OUTPUT}}{\text{INPUT}}$.
13. Efficiency is always less than 100%. Why? FRICTION, WATTS LOST IN MOTOR WINDINGS
14. If a lamp draws 2.5 amperes at 120 volts, how much power is consumed?

    a. 120 watts b. .0208 watts c. 300 watts (C) 300 WATTS

15. An electric heater is rated at 900 watts and operates on 120 volts. How much current does it use?

    a. 7.5 amps b. 10.8 amps c. .13 amps (A) 7.5 AMPS

16. An electric toaster uses 1200 watts and is rated at 10 amperes. The correct voltage for this appliance would be:

a. 110 volts b. 115 volts c. 120 volts (c) 120 VOLTS

17. Can six 200 watt lamps be connected in series on a 120 volt line? YES.

18. A motor draws 3 amperes as it operates at 250 volts. How much power is consumed? 750 WATTS. What is the horsepower rating of this motor? 1 HP.

19. How many kilowatts could a 400 horsepower generator produce? 300 KW.

SERIES CIRCUITS

DESIRED RESULTS:

To teach the student the relationship of voltage, current, and resistance in a series circuit.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Chalkboard
2. Dry cells (1.5 volts), "B" batteries, auto storage battery
3. Voltmeter, ammeter, ohmmeter
4. Wire for connections

INTRODUCTION:

Be sure that the students understand that:

1. The current is the same in any part of the circuit.
2. The total resistance is the sum of resistances in the various parts.
3. The total circuit voltage is the sum of the voltages in the various parts.

PRESENTING THE LESSON:

1. Show how cells may be connected to provide a higher voltage than is produced by one cell.
    a. Dry cells supply current at a pressure of 1.5 volts no matter what their size or shape. A single dry cell is therefore unsuitable when voltages greater than 1.5 volts are needed.
    b. Certain devices require higher voltages for their operation and will work at their maximum when operated at their rated voltage.
    c. Connect the cells in series.
        (1) The voltage resulting will be the sum of the voltage of individual cells.
            (a) Water pumps connected in series are like cells connected the same way. Each cell gives the current a "kick" and thus increases the flow of current in the circuit (rate of flow).
            (b) Flashlights, "B" batteries, and auto storage battery are examples of series connections.

2. The current in a series circuit is the same in all parts of the curcuit.
    a. Show this by using the Ohm's Law formula $I = \frac{E}{R}$.
    b. Draw a series circuit to show a resistance of 10 ohms, a 6 volt battery and an ammeter. Formula: $I = \frac{6}{10}$ or .6 ampere.
    c. If the ammeter is placed at any point in the circuit, it will read the same.
3. The total resistance of a series circuit is equal to the sum of the various resistances in the circuit. Expressed as R (totals) = $R_1 + R_2 + R_3$, etc.
    a. Point out that adding resistance to a series circuit reduces the current flow.
    b. That the current flow would read the same on an ammeter placed at any point in the series circuit.
    c. To find the current flow in a series circuit, it is necessary to know two things:
        (1) The circuit voltage
        (2) The total circuit resistance
4. Summary of the rules: See items 1, 2, and 3.
5. Show film--"Series Circuits."

APPLICATION:

Have the students work on problems and questions, and hand in the assignment sheet or exchange papers.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against answer sheets and return to learner for placing in workbook. Where needed, assign additional problems from Basic Mathematics by Singer.

NAME ____________________ LESSON NO. A-13

DATE ____________________ WORKSHEET A-13

SERIES CIRCUITS

1 True or False

a. In a series circuit, current remains the same throughout the circuit. TRUE.

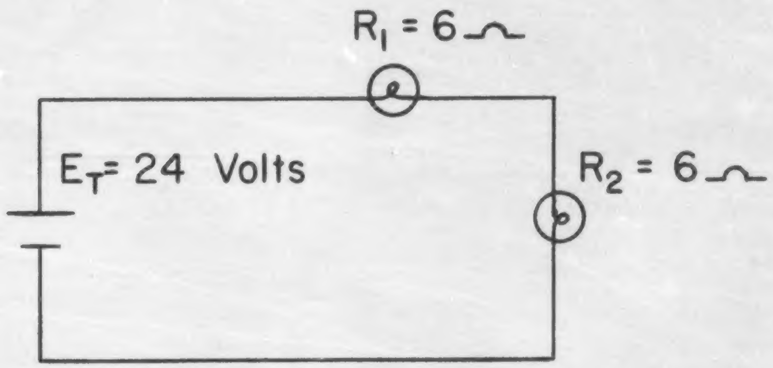
b. In a series set of Christmas lights, if one lamp burns out, the other lamp will continue to burn. FALSE.

c. Ohm's Law may be used to find the unknown values of all parts of a series circuit. TRUE.

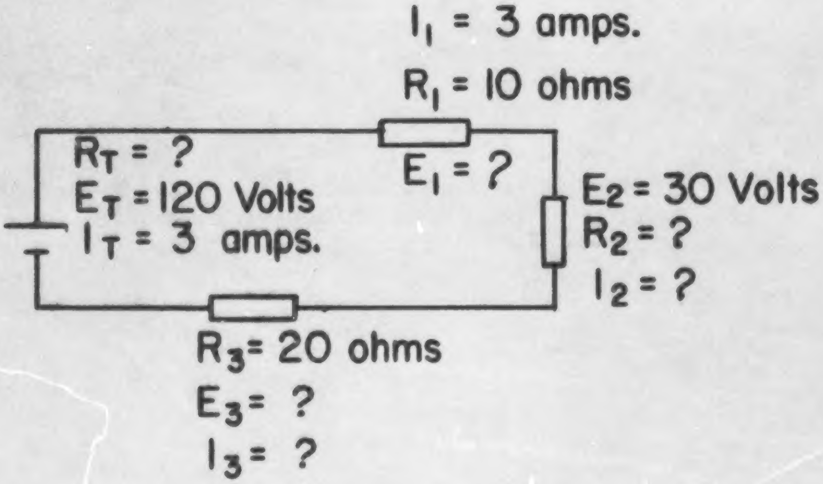
d. In a series circuit there is more than one path for current to flow. FALSE.

e. The total resistance is equal to the sum of all the resistors connected in the circuit when they are connected series. TRUE.

2. Solve for current: ANSWER: $I_T = 2$ AMPERES



3. **Solve for each unknown:**


I_1 = 3 amps.
R_1 = 10 ohms
E_1 = ?
R_T = ?
E_T = 120 Volts
I_T = 3 amps.
E_2 = 30 Volts
R_2 = ?
I_2 = ?
R_3 = 20 ohms
E_3 = ?
I_3 = ?

R_t = 40 OHMS

E_1 = 30 VOLTS

I_2 = 3 AMPS

R_2 = 10 OHMS

E_3 = 60 VOLTS

I_3 = 3 AMPS

4. **Describe the following symbols:**

a. E_t TOTAL VOLTAGE

b. I_1 CURRENT IN FIRST LOAD

c. R_4 RESISTANCE IN FOURTH LOAD

d. I_T TOTAL CURRENT

e. E_1 VOLTAGE DROP IN FIRST LOAD

f. E_4 VOLTAGE DROP IN FOURTH LOAD

g. R_T TOTAL RESISTANCE

5. A current of 3 amperes is flowing through a series circuit having four resistors with voltage drops across each respectively 12 volts, 15 volts, 30 volts, and 45 volts. Find total resistance and total voltage.

E_T = 102 VOLTS

R_T = 34 OHMS

6. A bell is designed to operate at 0.20 amps and 2.4 volts. Find the resistance to be connected in series with the buzzer in order to operate the buzzer on an eight volt source.

28 OHMS

PARALLEL CIRCUITS

DESIRED RESULTS:

1. To acquaint the student with the relationship of current, voltage, and resistance in a parallel circuit.
2. To understand that the total resistance of a parallel circuit is less than the smallest resistor.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Chalkboard
2. Dry cells (1.5 volts), wire, resistors, and lamp banks
3. Film—"Parallel Circuits," Modern Films, Charlotte, N. C.

INTRODUCTION:

The parallel circuit is another method of connecting electrical devices in a circuit. There are several ways of calculating the total resistance of a parallel circuit. To help the students to visualize the problems, it is well to require them to draw a circuit diagram for each problem. Many problems in this assignment are not long or complicated but will give the student good practice in OHM'S Law calculations. Present examples of these problems on the chalkboard, and give demonstrations using various resistors or lamp banks for loads. Measure the voltage and currents at various locations throughout the circuits.

PRESENTING THE LESSON:

Show several ways of calculating the total resistance of a parallel circuit with examples on the chalkboard. Explain that the understanding of more than one method of solving the problems will help them later with control and electronic work.

Show that two or more resistors of the same size or various sizes may be connected in parallel; the total resistance of a parallel circuit is ALWAYS less than the value of the smallest resistor.

Explain that in studying the theory of electricity, we often use a resistor in the circuit to represent the load. It is easier to draw the symbol for a resistor than a picture of an appliance.

Many demonstrations may be presented in conjunction with this lesson by using resistors of different values connected in various ways. In each circuit measure the total resistance with an OHMMETER and also calculate the resistance using the formula. Show the film, "Parallel Circuits," which is a good teaching aid. It will show animated current flow in PARALLEL circuits.

SUMMARY OF RULES FOR PARALLEL CIRCUITS:

1. The total current is the sum of the currents in various parts.
2. The voltage of a parallel circuit is the same in any part of the circuit.
3. The resistance is the reciprocal of the sum of the reciprocals of the various parts.

APPLICATION:

1. Discuss questions and applications presented by the films.
2. Have the students work the problems on the assignment sheet.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against answer sheets and return to learner for placing in workbook. Assign extra problems from Singer's Basic Mathematics, pages 98, 101, 118, 122, and 125, to those that need the extra practice.

NAME ______________________________ LESSON NO. A-14

DATE ______________________________ WORKSHEET A-14

PARALLEL CIRCUITS

1. True or False

   a. The current divides in a parallel circuit. TRUE.

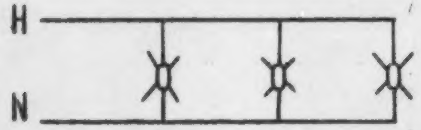
   b. In a parallel circuit the voltage drop is the same across each branch and is equal to the total voltage. TRUE.

   c. In a parallel circuit the total current is equal to the sum of the currents in each branch. TRUE.

   d. Parallel circuits are also identified as branch circuits. TRUE.

   e. The total resistance is always smaller than the smallest resistor connected parallel in a parallel circuit. TRUE.

2. Draw a circuit consisting of three lights connected parallel. Identify hot wire and neutral wire.



3. Write the two formulas for finding total resistance in parallel.

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2} \quad \text{or} \quad \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{ETC.}$$

4. Find the total resistance of a 20 ohm resistor and a 30 ohm resistor connected in parallel.

12 OHMS

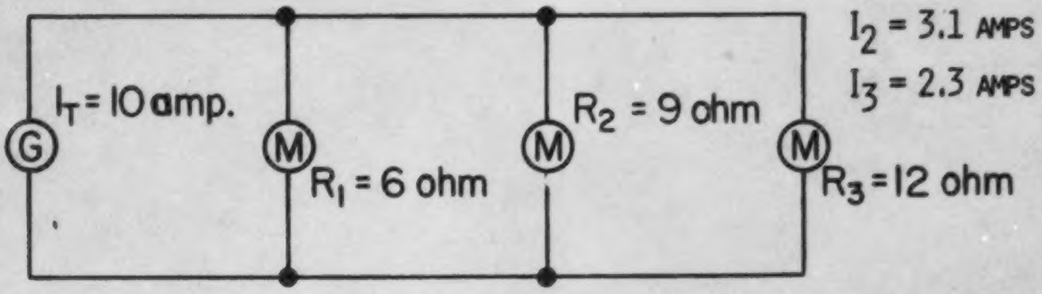
5. Find the current to each resistor of the following circuit.

ANSWER

I_1 = 4.6 AMPS

I_2 = 3.1 AMPS

I_3 = 2.3 AMPS


I_T = 10 amp.
G
M
R_1 = 6 ohm
M
R_2 = 9 ohm
M
R_3 = 12 ohm

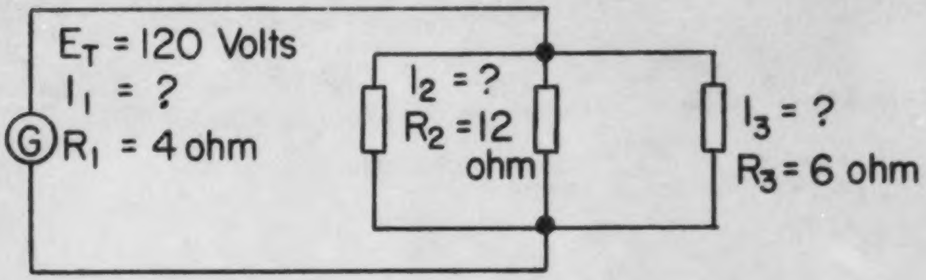
6. Find the total current and current in each branch of the following circuit.

ANSWER: I_1 = 30 AMPS

I_2 = 10 AMPS

I_3 = 20 AMPS

I_T = 60 AMPS

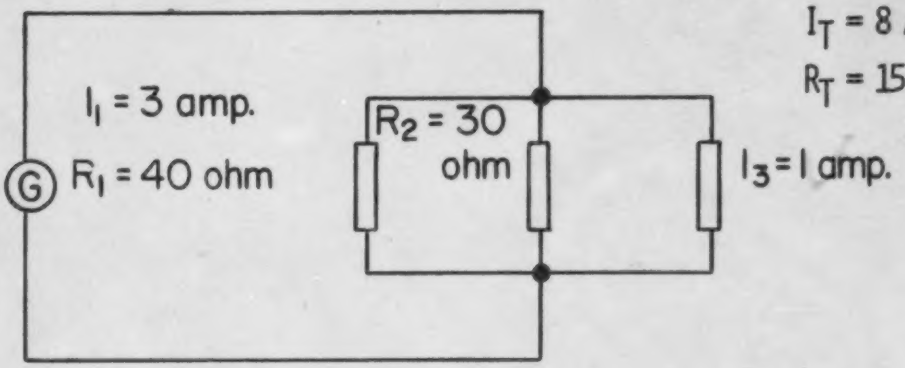

E_T = 120 Volts
I_1 = ?
G
R_1 = 4 ohm
I_2 = ?
R_2 = 12 ohm
I_3 = ?
R_3 = 6 ohm

7. Find the total voltage, total current and total resistance of the following circuit.

ANSWER: E_T = 120 VOLTS

I_T = 8 AMPS

R_T = 15 OHMS


I_1 = 3 amp.
G
R_1 = 40 ohm
R_2 = 30 ohm
I_3 = 1 amp.

COMBINATION CIRCUITS

(Series and Parallel Circuit Connections)

DESIRED RESULTS:

1. To acquaint the learner with the elementary problems of series and parallel circuits.
2. That the student learn to think in terms of and visualize the combination of series and parallel hookups.

MATERIAL, EQUIPMENT, AND SUPPLIES:

1. Chalkboard
2. Supplies for demonstrations
3. Large wiring charts, mock-ups, and models

INTRODUCTION:

Stress the understanding of the relationship of resistance, voltage, and current as in other OHM'S Law lessons.

The student should be well acquainted with the various methods of interconnecting circuits when greater amounts of voltage and current are needed. Most workmen deal with circuits in terms of parallel connections and become confused when they get into a combination of series and parallel hookups. Electrical energy, if wrongfully directed in a circuit, will oppose the direction of the desired current flow with harmful results.

PRESENTING THE LESSON:

The use of demonstrations, models, mock-ups, and large wiring charts will help greatly in presenting this lesson.

You may draw similar circuits on the chalkboard and ask the class to tell how the current and voltage would be distributed. It is recommended that some demonstrations be used with this lesson, if possible. The demonstrations can be applied to the material at hand by setting up a SERIES-PARALLEL CIRCUIT and making various readings throughout the circuit. Then calculate the voltage, current, or resistance of the circuit. This type of illustration will make a lasting impression on the student.

Remember to always work the SERIES and PARALLEL groups separately within the combined circuit and then solve for the whole combination.

NOTE: If you wish to use more practice problems for SERIES-PARALLEL combination, see Basic Mathematics by Singer, pages 136-138.

Show film--"Series and Parallel Circuits."

APPLICATION:

Have the students to answer questions and work the problems on the assignment sheet. Give individual suggestions where needed, but do not answer the question for the student.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against the answer sheets and return to the students. Assign extra problems if required.

NAME ______________________ LESSON NO. A-15

DATE ______________________ WORKSHEET A-15

COMBINATION CIRCUITS

1. List two disadvantages of series circuits.

   a. ANY PART OF THE CIRCUIT WHICH BURNS OUT CAUSES AN OPEN CIRCUIT AND PUTS THE ENTIRE CIRCUIT OUT OF OPERATION.

   b. CURRENT REMAINS UNCHANGED THROUGHOUT A SERIES CIRCUIT.

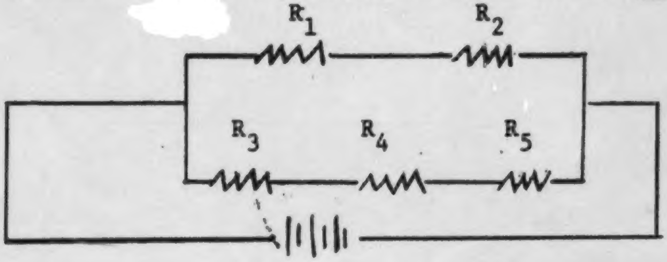
2. List two advantages of parallel circuits.

   a. MAY BE USED TO CONNECT SEVERAL SMALL VOLTAGES TOGETHER TO OBTAIN HIGH VOLTAGES.

   b. HIGH VOLTAGES MAY BE REDUCED BY CONNECTING RESISTANCES IN SERIES.

3. True or False

   a. The circuit bel[illegible]s a series parallel circuit. TRUE .



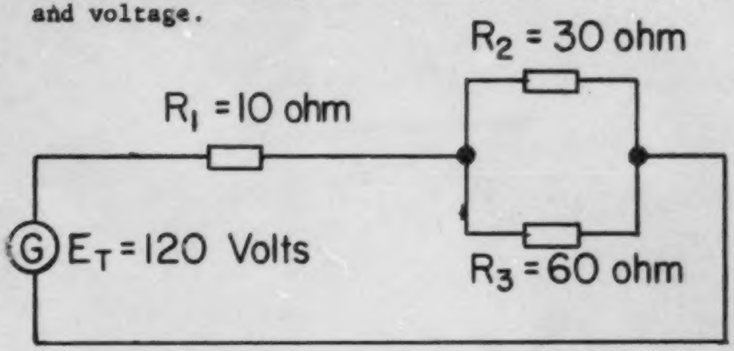
4. Find the total resistance of the circuit in question three if R_1 = 6 ohms, R_2 = 24 ohms, R_3 = 3 ohms, R_4 = 9 ohms, and R_5 = 18 ohms. 15 OHMS

5. List two functions a series circuit performs.

   a. REDUCES CURRENT IN A CIRCUIT

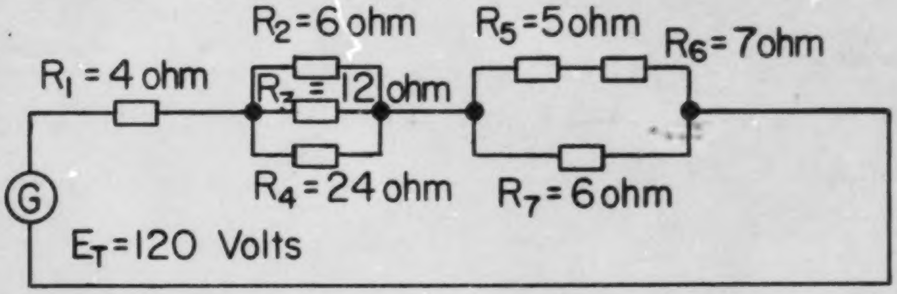
   b. CONTROLLS CURRENT IN A CIRCUIT

6. Solve the following circuit for all values of current, resistance, and voltage.

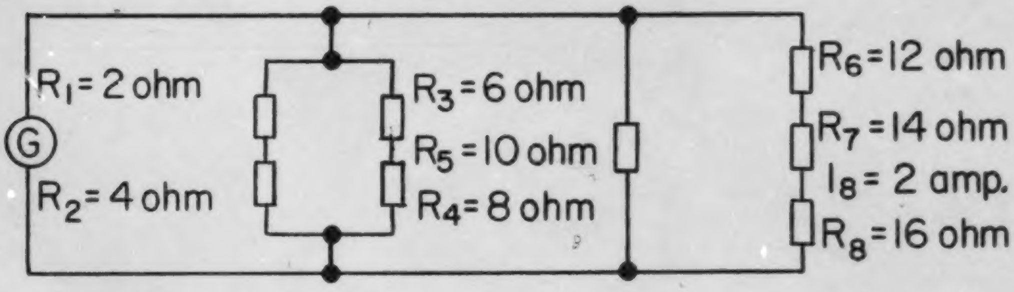

R_2 = 30 ohm
R_1 = 10 ohm
G
E_T = 120 Volts
R_3 = 60 ohm

E_1 = 40 volts
E_2 = 80 volts
E_3 = 80 volts
I_2 = 2.66 amps (appr
I_3 = 1.33 amps (appr
I_T = 4 amps
R_T = 30 ohms

7. Solve the following circuit for all values of current, resistance, and voltage. (Answers on page 46.)


R_2 = 6 ohm
R_5 = 5 ohm
R_6 = 7 ohm
R_1 = 4 ohm
R_3 = 12 ohm
G
R_4 = 24 ohm
R_7 = 6 ohm
E_T = 120 Volts

8. Solve the following circuit for all values of current, resistance, and voltage. (Answers on page 46.)


R_1 = 2 ohm
G
R_2 = 4 ohm
R_3 = 6 ohm
R_5 = 10 ohm
R_4 = 8 ohm
R_6 = 12 ohm
R_7 = 14 ohm
I_8 = 2 amp.
R_8 = 16 ohm

ANSWERS

7.

No.	R	E	I
1	4	42	10.5
2	6	36	6
3	12	36	3
4	24	36	1.5
5	5	17.5	3.5
6	7	24.5	3.5
7	6	42	7
T	11.43	120	10.5

8.

No.	R	E	I
1	2	28	14
2	4	56	14
3	6	36	6
4	8	48	6
5	10	84	8.4
6	12	24	2
7	14	28	2
8	16	32	2
T	2.76	84	30.4

WIRE CONSTRUCTION

(Paths for the Electric Current)

DESIRED RESULTS:

1. To acquaint the learner with the fact that all electrical devices receive their energy from a source by means of metallic conductors.
2. These conductors are separated or supported by nonmetallic materials called insulators.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Chalkboard and chalk
2. Samples of wire and insulators to be studied
3. Experimental materials to demonstrate "conductors and insulation"

INTRODUCING THE LESSON:

Call attention to the fact that wires are very much like pipes in that they permit the flow of electricity, but whereas pipes are hollow, wires are a solid. It is important to know the characteristics of these "electrical pipes," called conductors, and how they are made safe within the home and in appliances.

PRESENTING THE LESSON:

1. Electrical devices are connected to a source by wires to provide a path for the electric circuit.
   a. Make a sketch:
      (1) Two wires are needed to complete a circuit.
      (2) Electric current must flow from the source to the device and return to the source.
2. Electrical devices are made of different materials.
   a. Show
      (1) Difference of materials in an insulated wire.
      (2) Different materials in a plug.
      (3) Define materials such as metallic and nonmetallic
3. Demonstrate: "conductors and insulation"
   a. Samples of wire and insulating materials are studied.
   b. Experiment showing materials that conduct current and insulate current.

APPLICATION:

Have learner work and hand in the assignment sheet. Give individual help where needed.

CHECKING AND FOLLOW-UP:

Check assignment sheets against answer sheet and return to learner for placing in workbook.

NAME ______________________ LESSON NO. A-16

DATE ______________________ WORKSHEET A-16

WIRE CONSTRUCTION

1. A wire is a slender ROD or FILAMENT of drawn METAL.

2. A conductor is a wire or combination of wires not INSULATED from each other and suitable for carrying a SINGLE electric current.

3. One wire of any stranded conductor is called a STRAND.

4. Stranded conductors are more flexible than solid conductors. True/False TRUE.

5. A cable may be a SINGLE conductor or a GROUP of two or more conductors laid together but INSULATED from one another.

6. A small, flexible, insulated cable is called a CORD.

7. Wire sizes in this country are expressed in CIRCULAR MIL AREA This is the cross sectional area of the conductor.

8. A wire GAGE is used to determine the size of a wire or cable.

9. The larger the gage number, the SMALLER the size of the wire.

10. In this country we use the AMERICAN WIRE GAGE (AWG) as the standard measure of electrical wires.

11. List the six (6) most common metals used in the construction of wires and cables:

    (a) COPPER
    (b) ALUMINUM
    (c) BRONZE
    (d) IRON OR STEEL
    (e) COOPER-STEEL
    (f) ALUMINUM AND STEEL (ACSR)

12. Copper is the most commonly used material for wires and cables due to its its LOW resistance.

13. The three grades of hardness of copper wires are: (a) HARD DRAWN (b) MEDIUM HARD DRAWN (c) SOFT DRAWN OR ANNEALED.

14. If aluminum wires are used, a LARGER size wire may have to be used to carry the current necessary to serve the load.

15. One mil equals 1/1000 inches.

16. A circular mil is a unit of area equal to the area of a circle having a diameter of one MIL.

17. The area of a circle, in circular mils, is equal to the square of its diameter, in mils. True/False TRUE.

18. One square inch equals $\frac{4}{\pi}$ x 1,000,000 circular mils, or 1,273,200 circular mils. True/False TRUE.

19. The larger wire sizes are usually expressed in "thousands of circular mils." Abbreviated M C M.

20. The conductivity of copper used in electrical work is based on annealed copper wire. True/False TRUE.

21. A good conductor has high/low LOW resistance.

22. The longer the conductor, the greater/less GREATER the resistance.

23. Increasing the wire size raises/lowers LOWERS the resistance if the same load is applied.

24. Increasing the temperature will increase/decrease INCREASE the resistance of a conductor.

25. Four factors which affect resistance are:

(a) TEMPERATURE

(b) SIZE

(c) MATERIAL IT IS MADE OF

(d) LENGTH

WIRE INSULATION

DESIRED RESULTS:

1. To acquaint the student with a number of different types of wire, according to the insulation.
2. To teach the student to identify types of wire and sizes in general use on the job.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Chalkboard and chalk
2. Sample wire up to No. 4
3. Wire gages and a micrometer

INTRODUCTION:

1. The lesson should acquaint the student with the fact that there are different types of wire classed according to the insulation. Discuss the characteristics of an ideal insulating material.
2. Call attention to the fact that the size of wire is usually expressed according to some wire gage. However, it has become standard practice in the United States to employ the American Wire Gage, also known as the Brown and Sharpe, for designating copper and aluminum wire and cable used in the electrical industry.
3. Present the six major classes of wire and cables.

PRESENTING THE LESSON:

1. Show the class samples of as many types of wire according to the insulation as possible. Have each student examine the types of wire so he can classify wire according to insulation. Discuss the different types of insulation with the class.
2. Demonstrate to the class how to use the gage in measuring the size of wires. Wire gages are used for the measurement of diameters of wire and thicknesses of sheet metal. Wire sizes are referred to by gage numbers. The smaller the number, the larger the wire. Micrometers are gages for that purpose. Where micrometers are used, the wire diameters are expressed in thousandths of an inch.
3. The students should use the gages and micrometers to help identify wire sizes. They are expected to know sizes up to No. 4 on the job.

NOTE: A circular, mil (C.M.) is the area of a circle 1/1000 in. in diameter and is the unit for all wire measurement.

APPLICATION:

Have the students complete the answers to questions on the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against answer sheet and return to students for discussion and placing in notebooks.

NAME ____________________ LESSON NO. A-17

DATE ____________________ WORKSHEET A-17

WIRE INSULATION

1. The six major classifications of wire and cables are:

   (a) DEGREE OF COVERING
   (b) MATERIAL AND MAKE UP OF CONDUCTOR
   (c) NUMBER OF CONDUCTORS
   (d) INSULATION
   (e) PROTECTIVE COVERING
   (f) SERVICE USE INTENDED

2. Covered conductors are protected against mechanical injury only. Two examples of covered conductors are:

   (a) "WP" (b) "SB"

3. An insulated conductor is one covered with material RECOGNIZED as insulation.

4. What conductor has no covering or insulation? BARE

5. Conductors for electrical installations are generally made of COPPER or ALUMINUM.

6. Conductors # 8 and larger installed in raceways shall be stranded. Conductors # 10 and smaller may be solid or stranded.

7. Insulated conductors can either be single conductors or multi-conductor cables. True/False TRUE.

8. Three advantages of single conductor cables:

   (a) MORE FLEXIBLE
   (b) EASIER TO SPLICE
   (c) EASIER TO INSTALL

9. Three advantages of multiple conductor cables:

   (a) LOWER CABLE COST
   (b) SMALLER VOLTAGE DROP
   (c) MORE ECONOMICAL USE OF SPACE

10. What is used in multiple conductor cables to fill up the spaces between the conductors? FILLERS.

11. List the seven characteristics for an ideal insulating material:

(a) LONG LIFE
(b) HIGH DIELECTRIC STRENGTH
(c) RESISTS CORONA AND IONIZATION
(d) RESISTS HIGH TEMPERATURES
(e) MECHANICAL FLEXIBILITY
(f) RESISTS MOISTURE
(g) LOW COST - EASILY PRODUCED

12. Maximum voltage for insulated conductors in the National Electrical Code is 600 volts unless otherwise specified.

13. Rubber insulations listed in the National Electrical Code include those made from NATURAL and SYNTHETIC rubber, NEOPRENE and other vulcanizable materials.

14. Thermoplastic insulations are also listed in the National Electrical Code. True/False TRUE.

15. Match the following letters with the correct National Electrical Code wire trade names:

XHHW	6	1. Asbestos covered, heat resistant
V	7	2. Thermoplastic
THW	9	3. Heat resistant rubber
MI	5	4. Heat resistant thermoplastic
THHN	4	5. Mineral insulation
AF	1	6. Heat and moisture resistant cross-linked thermosetting polyethylene
FEP	8	7. Varnished cambric
RH	3	8. Fluorinated ethylene propylene
T	2	9. Moisture and heat resistant thermoplastic
RHW	10	10. Moisture and heat resistant rubber

16. What insulation provides the highest electrical breakdown strength, greatest reliability, and longest life of any insulating material? IMPREGNATED PAPER INSULATION.

17. The protective covering applied to some conductors offers additional insulation value. True/False FALSE.

18. Check the five factors used to determine the type insulation a conductor must have.

✓(a) Wet locations
✓(b) Dry locations
✓(c) Specific locations
✓(d) Special applications
✓(e) Temperature
(f) Altitude

19. Conductors with different insulation types can be used to make up a multi-wire circuit. True/False FALSE.

VOLTAGE DROP

DESIRED RESULTS:

1. To understand what is meant by voltage drop.
2. To be able to use the formula to determine excessive voltage drops.

MATERIALS AND EQUIPMENT:

1. Chalkboard
2. Voltmeter, lamp bank

INTRODUCTION:

The two factors that must be considered in determining the size of wire to be used in an electrical circuit are the current-carrying capacity of the wire and the permissible voltage drop.

The electrician always determines current-carrying capacity by consulting tables in the various electrical codes. On the other hand, voltage drop is nearly always calculated by the electrician himself. The National Electrical Code recommends that voltage drop from service head to distribution center be not more than one percent for lighting and three percent for power loads. These voltage drops should be limited to two percent. Voltage drop must be allowed when circuits are installed on commercial and industrial buildings, but is seldom considered for circuits on residential buildings.

PRESENTING THE LESSON:

In this lesson, the student will not learn all there is to be known about voltage drop. Teach them some of the basic facts so they can learn to figure voltage drop and how voltage drop is used in calculating the sizes of wires required for certain circuits. Spend enough time on this lesson to be sure that the students understand how to use the formula for finding voltage drop.

Introduce the following formula by writing it on the chalkboard and explaining its use.

$$VD = \frac{2K \times I \times L}{CM}$$

VD = Voltage drop
K = Resistance (1 mil foot of wire)
I = Amperes
L = Distance of wire one way
CM = Circular mils

Work several problems illustrating how to solve for various unknowns.

Note 1: If the students have trouble rearranging the formula, it is much easier for some to substitute in the original form and solve for the unknown.

Note 2: By use of the formula, we find voltage drop, but the National Code recommendations give PERCENTAGE voltage drop.

APPLICATION:

The students will answer questions and work problems on Assignment Sheet A-18.

CHECKING AND FOLLOW-UP:

Correct the assignment sheet. Be sure to give assistance to those that had trouble.

NAME________________________________ LESSON NO. A-18

DATE________________________________ WORKSHEET A-18

VOLTAGE DROP

1. Voltage drop in an electrical circuit: (A) CAN BE LIMITED

   (a) Can be limited
   (b) Can be eliminated
   (c) Is of little importance
   (d) Has no connection with power loss

2. The National Electrical Code permits a feeder voltage drop of not more than 3 % for power, heating or lighting loads and the maximum total voltage drop for feeders and branch circuits should not exceed 5 %.

3. The feeder voltage drop is measured from the service entrance to the branch panelboard. True/False TRUE.

4. A branch circuit voltage drop would be from the branch panelboard to the center of the branch circuit load. True/False TRUE.

5. Voltage drop at a load is equal to the supply voltage minus the SERVICE VOLTAGE.

6. Voltage drop calculations are usually not necessary for residential and small commercial work unless the branch circuit run exceeds 50 feet to the center of the load.

7. Under most circumstances the resistance of an AC circuit is equal to a DC circuit when calculating voltage drop. True/False TRUE.

8. Which of the following items are not needed in calculating voltage drop? (f) AN ELECTROLYTE (E)

   (a) Circular-mil area of wire (D)
   (b) Distance to the load (one way) expressed in feet (L)
   (c) Current in amperes (load) (I)
   (d) Voltage drop allowed (V)
   (e) Resistance per OHM foot for the conductor (R)
   (f) An electrolyte (E)
   (g) Resistivity of conductor cir mil-Ohms/ft. (K) use "12"

9. The following are formulas for two wire single phase circuits:

   (a) $V= \frac{2KxLxI}{D^2}$
   (b) $L= \frac{VxD}{2KxI}$
   (c) $I= \frac{VxD}{2KxL}$
   (d) $D^2= \frac{2KxLxI}{V}$

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10. The voltage drop in a 3 phase 4 wire circuit when the loads are nearly balanced is the same as a two-wire single phase circuit. True/False TRUE.

11. Listed below are standard circuit distances allowed:

Wire Size	Distance	
	120V	277V
#12	0' - 50'	0' - 110'
#10	51' - 80'	111' - 180'
# 8	81' - 140'	181' - 250'

12. The voltage drop in a 3 phase 3 wire circuit is the same as a 2 wire single phase circuit multiplied by 0.866. True/False TRUE.

13. What size copper wire is required in a 120 volt circuit to transmit 20 amperes a distance of 130 feet, with a voltage drop of 3 percent?

(a) # 10
(c) # 8
(b) # 12
(d) #14

14. What is the maximum current in a 120 volt circuit in which two #10 copper wires transmit this current a distance of 100 feet with a voltage drop of 2 percent?

(a) 30.2 amps
(c) 13.3 amps
(b) 11.5 amps
(d) 26.4 amps

15. A load is connected to one of the phase wires and to the neutral wire of a 4 wire 3 phase system. What formula should be used for determining the voltage drop in this circuit?

$$V = \frac{2K \times L \times I}{D^2}$$

16. A group of fluorescent fixtures is located 400 feet from the source, which is 120 volts. If these fixtures draw 18 amperes and a voltage drop of 2 percent is desired, what size wire should be used?

(a) # 8
(c) # 2
(b) # 7
(d) # 5

INTRODUCTION TO NATIONAL ELECTRICAL CODE

DESIRED RESULTS:

1. To acquaint the apprentice with the purpose and scope of the CODE.
2. To introduce the apprentice to the definitions and fundamental rules covered by the CODE.

INTRODUCTION:

This is the apprentice's first contact with the NATIONAL ELECTRICAL CODE He will be working by these rules for his entire life in the electrical industry. The importance of learning the purposes and organization of the CODE cannot be over emphasized.

This lesson should give the student a clear picture of how the CODE is organized so that the apprentice may find information more easily in later assignments and on the job. The CODE is not a set of laws; it is a set of rules. It is intended for use by governmental bodies exercising legal jurisdiction over electrical installations and for use by insurance inspectors.

Article 100 contains definitions of electrical terms.

PRESENTING THE LESSON:

In the National Electrical Code Book - Article 90, which is the introduction, outlines the purpose and explains the scope of the CODE.

The best results will be obtained from all CODE lessons if they are used as study guides for the student. The instructor should lead a class discussion of the material contained in each section of the CODE used in the assignment.

After discussing the sections and giving illustrations from your experience, then the assignment sheet with specific questions can be distributed.

Remind the students that the chief electrical inspectors usually exercise legal jurisdiction over electrical installations through city ordinances or laws based on National Electrical Code. Some communities use the CODE as it is for their local electrical ordinance. Most citizens realize that the CODE is only the minimum standard so they improve on certain portions for their use. If the electrician knows the National Electrical Code, he may be able to work in any locality, but he should become familiar with local ordinances.

APPLICATION:

Have the students answer the specific questions using the assignment sheet, A-19, which is an introduction to the National Electrical Code.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in the workbook.

NAME ______________________ LESSON NO. A-19

DATE ______________________ WORKSHEET A-19

INTRODUCTION TO NATIONAL ELECTRICAL CODE

1. The purpose of the code is the practical safeguarding of persons, and of buildings and contents from dangers arising from use of electricity. True/False. TRUE

2. The code covers installations by electric utilities. True/False. FALSE

3. The code is not intended as an instruction manual for: (D)

   (a) qualified electricians (c) contractors

   (b) inspectors [✓ (d) untrained persons]

4. The code is revised periodically: (C)

   (a) 5 yrs. (b) 2 yrs. [✓ (c) 3 yrs.] (d) 1 yr.

5. The code covers electrical conductors and equipment installed within public and private buildings. True/False. TRUE

6. Equipment that can be removed or adjusted without disturbing the building structure or finish is called: (A)

   [✓ (a) accessible] (c) enclosed

   (b) permanent (d) weatherproof

7. A FIXED APPLIANCE is utilization equipment at a specific location installed to perform one or more functions.

8. APPROVED equipment is acceptable to the authority enforcing the code.

9. A conductor having no covering or insulation is a BARE conductor.

10. What is a disconnecting means?

    A DEVICE WHEREBY THE CONDUCTOR OF A CIRCUIT IS DISCONNECTED FROM THE SOURCE OF SUPPLY.

11. ENCLOSED equipment is surrounded by a case which will prevent a person from accidentally contacting live parts.

12. Exposed wiring is concealed. True/False. FALSE

13. A ground fault is a conducting connection between an electrical circuit and the earth. True/False. TRUE

14. The grounded conductor is intentionally connected to the earth and is also called "IDENTIFIED CONDUCTOR" or "NEUTRAL."

15. An equipment ground conductor is called: (C) GROUNDING CONDUCTOR

(a) neutral conductor
(c) grounding conductor
(b) identified conductor
(d) white color conductor

16. Raceways are designed for carrying cables, wires, or busways. True/False. TRUE

17. What is a remote controlled circuit? ANY ELECTRICAL CIRCUIT WHICH CONTROLS ANOTHER CIRCUIT THROUGH A RELAY OR EQUIVALENT DEVICE.

18. Draw a line to match the following:

(a) Service Cable	Overhead service conductor between the last pole and first point of attachment to the building.
(b) Service Drop	Service conductors made up in the form of a cable.
(c) Service Entrance	Conductors between the terminals of the service equipment and tap to overhead service drop.

19. Service equipment is not located near the point of entrance of supply conductors to a building, but is always located in the northeast corner. True/False. FALSE

20. Service equipment is intended to constitute the main control and means of cutoff for power supply to the building. True/False. TRUE

21. A gerneal use switch is capable of interrupting its rated current at rated voltage and is rated in: (B) AMPERES

(a) horsepower

(b) amperes

(c) watts

(d) ohms

22. A motor circuit switch is rated in: (A) HORSEPOWER

(a) horsepower

(b) watts

(c) amperes

(d) miles per hour

23. What is the difference between watertight and weatherproof equipment? WEATHERPROOF PROTECTS FOR SUCCESSFUL OPERATION AGAINST EXPOSURE TO MOISTURE AND WATERTIGHT PREVENTS MOISTURE FROM ENTERING THE EQUIPMENT.

24. Working spaces adjacent to exposed live parts may be used for stroage if it's a dry location. True/False. FALSE

25. All wiring shall be installed free from SHORT CIRCUITS and GROUNDS.

26. Equipment mounted a minimum of 8 feet above the floor usually affords good protection, in guarding live parts.

27. Electrical equipment should be installed in a neat and workmanlike manner. True/False. FALSE ("SHALL")

GENERAL REQUIREMENTS FOR WIRING INSTALLATIONS

DESIRED RESULTS:

To acquaint the apprentice with the general requirements for wiring methods and installations.

INTRODUCTION:

In the U.S.A., cable wiring is probably the most recognized wiring method, especially for residential-type construction. Local ordinances in some cities may limit the extent of its use, but cable wiring in some form is recognized in almost every place where electrical power is available. The general requirements for wiring methods are listed in the National Electrical Code, Article 300.

This assignment contains information about overcurrent protective devices and fuses, sizes of conductors, types of conduit, installing boxes, grounds and grounding, and various raceways. This information will be very useful to the apprentice in his daily work on the job.

The student may not realize the fact, but it requires a skilled craftsman to make a concealed electrical installation in an old building. It is essential that he leave the building in good repair when he is finished.

PRESENTING THE LESSON:

The instructor should lead a class discussion of the material found in the assignment. The students should have read the assignment and have questions for discussion ready to present.

Use American Electricians' Handbook, Division 9 and National Electrical Code, Article 300 and 310 as study guides for this assignment.

There are twenty-two types of wiring for general use for power and light systems.

1. Call attention to the method of determining the minimum and maximum size of conduit for interior installations. The current capacity of a conductor is limited by the temperature its insulation will withstand.
2. The National Electrical Code requires that fuses or circuit breakers be provided for all ungrounded conductors to open the circuit when the current is abnormally high.

3. Conduit systems contain both junction and outlet boxes. A junction box is placed where several conduit runs intersect. It provides means for pulling in the wire and serves as an enclosure for the connections that must be made. It is possible to ground the entire system with one ground connection. Outlet boxes may be used to enclose a switch which controls the current in a circuit or fitted with outlets and special cover through which light and power loads can be connected.
4. Grounding is executed by connecting one wire from a wiring system or the metallic covering of electrical devices to a steel beam of a building, to a ground strap fastened to a water pipe, or a pipe driven in the ground. Grounding is necessary to protect life and property.

APPLICATION:

Have the students find the answers to the questions on the assignment sheets. This may take two meetings.

CHECK AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME ______________________________ LESSON NO. A-20

DATE ______________________________ WORKSHEET A-20

GENERAL REQUIREMENTS FOR WIRING INSTALLATION

1. What is the minimum size conductor for interior wiring work? (B) 14

   (a) 18 (b) 14 (c) 12 (d) 10

2. What is the maximum size for solid conductors in conduit? (A) 10

   (a) 10 (b) 6 (c) 8 (d) 500 MCM

3. List two advantages of No. 12 AWG conductors over minimum size conductor:

   (a) GREATER MECHANICAL STRENGTH, REDUCES I^2R HEATING LOSS

   (b) REDUCES VOLTAGE DROP

4. What advantage does a stranded conductor have? (a) EASE IN HANDLING

   (a) Ease in handling (c) cheaper

   (b) red in color (d) hard to bend

5. All ungrounded and grounded conductors shall be protected by fuses or circuit breakers. True/False. FALSE

6. What position shall enclosures for overcurrent devices be mounted? (A) VERTICAL

   (a) vertical (c) Anniegoggling

   (b) horizontal (d) Caddiwampus

7. Fuses shall not be mounted in rosettes. True/False. TRUE

8. Fuses and circuit breakers shall be located or SHIELDED to prevent BURNS or DAMAGE by their operation to persons.

9. Minimum size flexible cord shall be: (E) 27

   (a) 20 (b) 250 MCM (c) 18 (d) 16 (e) 27

10. Conductors shall not be spliced or taped within the raceway or conduit. True/False. TRUE

11. Minimum size conductor permitted to be connected in parallel is: (C)

(a) 14 (b) 3/0 (c) 1/0 (d) 18

12. If parallel conductors are run in separate conduits, one wire of EACH PHASE shall be installed in each conduit.

13. Grouping of conductors by phases in parallel runs in separate conduits will cause overheating to parts of metal by: (B) INDUCTION

(a) Voltage (c) Power

(b) Induction (d) Ohms

14. How many inches of free conductor should each outlet have: (D)

(a) 5 inches (c) 2 inches

(b) 3 inches (d) 6 inches

15. Underground conductors, No. 4 AWG or larger, entering a cabinet shall be protected by an INSULATING BUSHING.

16. Article 300-3-A covers: (C)

(a) Maximum Amperes (c) Conductor Insulation

(b) Maximum Watts (d) Raceway Size

17. The test for insulation resistance is made with a: (A) MEGGER

(a) Megger (c) Ammeter

(b) Voltmeter (d) Ohmmeter

18. In general, all interior wiring systems shall have grounded conductor that must be continuously IDENTIFIED throughout the system.

19. Article 200-10 covers: 3 of the list below. Which one does it not cover.

(a) Lights (c) Screw shell connections

(b) Plugs (d) Swimming pools

20. All conduits must be continuous from outlet to outlet. True/False.
TRUE

21. Match the following letter that corresponds with the numbers:

C	1. Article 300-11	a.	Fixture weight support.
D	2. Article 370-13	b.	Fixture support more than 50 pounds
A	3. Article 410-15	c.	Securing boxes and fittings
B	4. Article 410-16	d.	Securing conduit

22. The maximum No. 12 AWG conductors permitted in an outlet box 2-1/8 x 4-11/16 square shall be: (E) 18

(a) 20 (c) 15 (e) 18
(b) 25 (d) 10

23. All junction boxes shall be installed with the wiring ACCESSIBLE.

24. Boxes installed in wood walls shall be set flush; and in tile walls the box shall be set back 1/4 inches.

25. Gutters shall be supported at intervals not exceeding: (B) 5 FEET

(a) 6 feet (c) 10 feet
(b) 5 feet (d) 4 feet

26. Electric furnace circuits are not required to be grounded. True/False. FALSE.

27. Match the following wire colors by matching the letter that corresponds with the number:

A	1. Identified ground or neutral	a.	White
B	2. Equipment ground	b.	Green
C	3. Hot or ungrounded wire	c.	Red, black, etc.

28. There shall be a ground at each building service on the supply side of each service switch and a minimum size of No. (A) 8.

(a) 8 (b) 6 (c) 14 (d) 20

29. How many grounding conductors shall be connected to the grounding electrode by a single fitting? (B) 1

(a) 3 (b) 1 (c) 5 (d) None

30. No switch shall be installed in a grounded conductor. True/False.
TRUE

31. Match the following letter that corresponds with the number:

D	1. Article 300-18	a. Sealing raceways
C	2. Article 300-19	b. Splices and taps
B	3. Article 374-8	c. Vertical conductor support table
A	4. Article 300-7	d. Conductors installed in raceways

SINGLE CONDUCTOR WIRING

DESIRED RESULTS:

1. To learn the definition and use of open wiring on insulators, and concealed knob-and-tube work.
2. To acquaint the apprentice with the construction and restrictions in the use of single conductor wiring.

PRESENTING THE LESSON:

Open wiring on insulators may be used for exposed work, either inside or outside buildings and in dry or wet locations. Open wiring on insulators shall not be used in (1) commercial garages, (2) theaters, (3) motion picture studios, (4) hoistways, and (5) hazardous locations.

Concealed knob-and-tube work may be used in hollow spaces of walls and ceilings. It has the same restrictions as open wiring.

APPLICATION:

Have the students complete the worksheet, A-21, adapted to this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students to correct and place in their notebooks.

NAME ______________________________ LESSON NO. A-21

DATE ______________________________ WORKSHEET A-21

1. Single conductor wiring can be either exposed or concealed. True/False TRUE.

2. Single conductor wiring can be used for both branch circuit and feeder wiring. True/False TRUE.

3. Can a bare conductor be used for single conductor wiring? Yes/No NO. Give the Code Section for your answer. 320-1.

4. Single conductor wiring is restricted to residential wiring only. True/False FALSE.

5. The conductor separation for open wiring for voltage not exceeding 300 volts is 2 1/2 inches, and for voltage not exceeding 600 volts is 4 inches.

6. Tie wires for open or concealed wiring do not have to be insulated. True/False FALSE.

7. Open wiring passing thru floors and walls can be bunched together in a single sleeve. True/False FALSE.

8. Conductor separation for concealed knob and tube work is the same as open wiring. True/False FALSE.

9. Splices and taps in open and concealed wiring can be made only in outlet boxes. True/False FALSE.

10. The maximum length of flexible non-metallic tubing allowed is 15 feet. It must be secured with straps spaced not more than 4 1/2 feet apart.

11. Single conductor wiring may be attached to non-metallic water piping on the bottom side. True/False FALSE. Give the N. E. Code Section for your answer. 320-12.

12. Open or concealed knob-and-tube wiring current ampacity is the same as conductors installed in metal conduit. True/False FALSE. Give the N. E. Code Section for your answer. 324-5

13. Open conductor feeders are the least expensive way to install large size feeders in industrial jobs. True/False FALSE. Explain your answer. CONDUCTOR SUPPORTS AND EQUIPMENT GROUNDING CONDUCTORS ALONG WITH ADDED LABOR FOR MULTIPLE RUNS OF SINGLE CONDUCTORS MAKE THE JOB COST MORE BUT THE AMPACITY OF THE WIRE IS GREATER.

14. Single conductor wiring cannot be electrically connected with a metallic raceway system. True/False FALSE.

CABLE ASSEMBLIES

DESIRED RESULTS:

To acquaint the apprentice with the construction and restrictions in the use of the various cable assemblies.

MATERIALS:

Have samples of the cables to show the class.

PRESENTING THE LESSON:

1. A nonmetallic sheathed cable is an assembly of two or more insulated conductors having an outer sheath of moisture-resistance, flame-retardant, nonmetallic material.
2. A service-entrance cable is a conductor assembly provided with a suitable overall covering, primarily used for services of the following types:
   a. Type SE, having a flame-retardant, moisture-resistant covering.
   b. Type USE, having a moisture-resistant covering and recognized for underground use.
3. An underground feeder and branch circuit shall be an approved type UF cable in sizes No. 14 to No. 4/0 AWG, inclusive. When this cable is used for grounding purposes only, it may be an approved size of uninsulated or bare conductor.

APPLICATION:

Have the students complete the answers to the questions on the worksheet. Use the Code book when it is needed.

CHECKING AND FOLLOW-UP:

Check the answers and return the worksheets to the students for correction.

NAME________________________________ LESSON NO. A-22

DATE________________________________ WORKSHEET A-22

CABLE ASSEMBLIES

1. The code designations on non-metallic sheathed cable are:

   (a) N. M.
   (b) N. M. C.

2. The basic difference in the two cables listed above is AN OVERALL COVERING OF FLAME RETARDANT AND MOISTURE RESISTANT FINISH.

3. Conductor sizes for non-metallic sheathed cable range from # 14 thru # 2 for copper conductors and # 12 thru # 2 for aluminum conductors.

4. The uninsulated or bare conductor is for GROUNDING purposes only.

5. There may be two or more insulated conductors in a non-metallic sheathed cable. True/False TRUE.

6. The insulation of the individual conductors shall comply with the requirements for the type of conductors used. True/False TRUE.

7. The code designations of service-entrance cable are (a) S. E., (b) U.S. E..

8. The basic difference in the two cables listed above is TYPE U. S. E. IS RECOGNIZED FOR UNDERGROUND USE.

9. Which of these cables is required to have inherent protection against mechanical abuse? NEITHER ONE.

10. The identified conductor in a service entrance cable may be smaller than the ungrounded conductors. True/False TRUE.

11. Can the uninsulated conductor of service entrance cable used as a branch circuit be used as the neutral. Yes/No NO.

12. Can single conductors having approved insulation be installed as underground service entrance conductors? Yes/No YES.

13. Underground feeder and branch circuit cable has the code designation of type U.F..

14. Sizes for these cables range from # 14 AWG to # 4/0 AWG inclusive.

15. What is the minimum depth for cables buried directly in the earth? 24 INCHES. Can this depth be reduced? Yes/No YES.

16. If the second answer in question #15 above is yes, explain what requirements must be met.
BY PROVIDING PROTECTIVE COVERING SUCH AS A 2" CONCRETE PAD, METAL RACEWAY, PIPE, OR OTHER SUITABLE PROTECTION.

17. Under what conditions can underground feeder and branch circuit cable be installed in cable tray?

IT SHALL BE OF THE MULTIPLE CONDUCTOR TYPE.

18. All underground feeder and branch circuit cable is approved for exposure to direct rays of the sun. True/False FALSE.

19. The current carrying capacity of the conductors covered in this assignment are those listed in Tables 310-16 Thru 310-19 True/False TRUE.

20. Type SNM cable is a factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant, non-metallic material, covered with an overlapping spiral metal tape and wire shield, and jacketed with an approved non-metallic material.

21. The above cable has two special uses--list them.

(a) WIRING IN RIGID CABLE SUPPORTS (CABLE TRAY) OR IN RACEWAYS

(b) IN HAZARDOUS LOCATIONS

22. Type FC cable is an assembly of parallel conductors formed integrally with an insulating material web.

23. The above cable is used for branch circuit wiring to supply:

(a) LIGHTING

(b) SMALL APPLIANCES

(c) SMALL POWER LOADS

24. The cable may have three or FOUR conductors of special # 10 AWG copper wire protected by a branch circuit of not more than 30 amperes.

METALLIC SHEATHED CABLES

DESIRED RESULTS:

To acquaint the apprentice with the definition and use of the various metallic sheathed cables.

MATERIAL:

Samples of the cables

PRESENTING THE LESSON:

1. Mineral insulated - metal sheathed cable - Type Ml
   This is a cable in which one or more electrical conductors are insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight metallic tube sheathing. It may be used for services, feeders, and branch circuits in both exposed and concealed work and in dry and wet locations.
2. Aluminum sheathed cable - Type ALS
   This cable is factory assembled, consisting of one or more insulated conductors enclosed in an impervious, continuous, closely fitting tube of aluminum. It may be used with approved fittings for terminating and connecting to boxes, outlets, and other equipment. This cable may be used in both exposed and concealed work and in dry and wet locations.
3. Metal-clad cable - Type MC and AC series
   This is a fabricated assembly of insulated conductors in a flexible metallic enclosure. The uses are explained in the Code book.

APPLICATION:

Have the apprentices to study the assigned Code articles for the uses of these cables. Give special attention to type MC and AC cables. Then they will answer the questions on the worksheet.

CHECKING AND FOLLOW-UP:

Check the answers on the worksheets and return to the apprentices for future references.

NAME______________________________ LESSON NO. A-23

DATE______________________________ WORKSHEET A-23

METALLIC SHEATHED CABLES

1. Listed below are the code type designations and descriptions. Draw a line to connect the correct type with its description.

ALS	Armored cable
MI	Armored cables with lead covered conductors
ACT	Metal clad cable
MC	Mineral insulated cable
ACL	Armor clad cable with thermoplastic conductors
AC	Aluminum sheathed cable

2. The three basic metallic sheathing metals used in the protective covering are:

(a) ALUMINUM

(b) COPPER

(c) GALVANIZED STEEL

3. This metallic sheathing can be used as an equipment grounding conductor. True/False TRUE.

4. This metallic sheathing can be used as a current carrying conductor (a "neutral" could be a current carrying conductor). True/False FALSE.

5. The conductor insulation must be suitable for the use and location. True/False TRUE.

6. The mineral insulation used in type MI cable is MAGNESIUM OXIDE.

7. The individual conductors of multi-conductor type MI cable have no individual insulation. True/False TRUE.

8. The cable termination fittings for all types of metallic sheathed cables are identical. True/False FALSE.

9. Which two of the metallic sheathed cables require a special approved insulating bushing?

(a) A C (b) M C

10. Which one of the metallic sheathed cables is approved for Class I, II, and III hazardous locations? M I CABLE.

11. Which two types of metallic sheathed cables are approved for installation underground without supplemental corrosion protection?

(a) MC (b) MI

12. All types of metallic sheathed cables are approved for dry locations. True/False TRUE.

13. What are the four major insulating materials used for conductor insulation?

(a) RUBBER

(b) THERMOPLASTIC

(c) VARNISHED CLOTH

(d) MAGNESIUM OXIDE

14. The three basic types of sheathing used on metallic sheathed cable are:

(a) INTERLOCKING METAL TAPE

(b) CORRUGATED TUBING

(c) SMOOTH TUBING

15. The support methods for metallic sheathed cables are the same as other cable assemblies. True/False TRUE.

16. The trade name for type AC cables is BX.

17. Can the outer Sheath of MC type cable be used for Equipment Grounding purposes? [✓ Yes]/No

SPECIAL CORDS AND WIRES

DESIRED RESULTS:

To acquaint the apprentice with the trade names, construction, and restrictions in the uses of flexible cords and fixture wires.

MATERIALS:

Samples of material to be studied
National Electrical Code Book (latest edition)

PRESENTING THE LESSON:

1. Discuss flexible cords, the trade names, size, conductors, insulation, and outer covering. (Use the Code book.)
2. Discuss fixture wire, the trade names, type letter for designation, insulation and thickness, type of outer covering. (Use the Code book.)

APPLICATION:

Using the assignment or worksheets, have the class complete the questions. (Use Code book.)

CHECKING AND FOLLOW-UP:

Check the answers on the worksheets and return them to the apprentices to correct and place in their notebooks.

NAME ______________________________ LESSON NO. A-24

DATE ______________________________ WORKSHEET A-24

SPECIAL CORDS AND WIRES

1. Flexible cords and cable types are described where in the Code Book? TABLE 400 - 4.

2. List the eight (8) approved uses for flexible cord.

   (a) PENDANTS.

   (b) WIRING OF FIXTURES.

   (c) CONNECTION OF PORTABLE LAMPS OR APPLIANCES.

   (d) ELEVATOR CABLES.

   (e) WIRING OF CRANES AND HOISTS.

   (f) CONNECTION OF STATIONARY EQUIPMENT TO FACILITATE THEIR FREQUENT INTERCHANGE.

   (g) PREVENTION OF TRANSMISSION OF NOISE OR VIBRATION.

   (h) FACILITATING THE REMOVAL OR DISCONNECTION OF FIXED OR STATIONARY APPLIANCES FOR MAINTENANCE OR REPAIR.

   (i) DATA PROCESSING CABLES (ALTERNATE ANSWER).

3. When flexible cord is used to serve an appliance or lamp the cord will be equipped with an attachment plug. True/False. TRUE.

4. List five (5) uses of flexible cords prohibited by the Code.

   (a) AS SUBSTITUTE FOR FIXED WIRING OF A STRUCTURE.

   (b) RUN THRU HOLES IN WALLS, CEILINGS OR FLOORS.

   (c) RUN THRU DOORWAYS, WINDOWS, OR SIMILAR OPENINGS.

   (d) ATTACHED TO BUILDING SURFACES.

   (e) CONCEALED BEHIND BUILDING WALLS, CEILINGS, OR FLOORS.

5. Splices can be made in flexible cord. True/False. TRUE.

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6. Tying a knot in the conductors of a flexible cord to keep strain off the terminal screws is prohibited by the Code. True/False. FALSE.

7. A flexible cord containing more than three (3) current-carrying conductors has to be de-rated. True/False. TRUE.

8. What are the five major insulating materials used in flexible cords?

(a) RUBBER

(b) THERMOPLASTIC

(c) ASBESTOS

(d) COTTON

(e) VARNISHED CAMBRIC

9. All flexible cords have an outer covering. True/False. FALSE.

10. All flexible cords have a grounding conductor. True/False. FALSE.

11. In a five conductor flexible cord there could be five different colored conductors as listed below. Give the proper name for the intended use of each colored conductor:

(a) Black PHASE CONDUCTOR

(b) Red PHASE CONDUCTOR

(c) Blue PHASE CONDUCTOR

(d) White GROUND CONDUCTOR (NEUTRAL)

(e) Green GROUNDING CONDUCTOR (EQUIPMENT GROUND)

12. What are the four approved insulations for fixture wires?

(a) RUBBER-NATURAL

(b) RUBBER-SYNTHETIC

(c) NEOPRENE

(d) OTHER VULCANIZED MATERIAL

13. Which of the above insulation types offers the highest ampacity rating? SF (SILICONE RUBBER)

14. What section of the Code permits the use of a #16 or #14 AWG fixture wire being protected by a 20 ampere overcurrent protective device? SECTION 240-4.

15. Fixture wires can be used as branch circuit conductors. True/False. FALSE..

RIGID METAL CONDUIT

DESIRED RESULTS:

To acquaint the apprentice with some of the techniques connected with conduit installations that must be learned through experience.

INTRODUCTION:

Single family dwellings are seldom wired completely with rigid metal conduit because of the high cost of such an installation. However, is is widely used in industrial plants. Electrical metallic tubing is sometimes employed because the cost of labor for installation is much less than for rigid conduit. The cost is still somewhat higher than that for a knob-and-tube or a cable-type installation.

It is common practice to install a rigid conduit or an electrical metallic tubing service raceway even though the bulk of the installation is carried out by some other method of wiring.

Hydraulic Conduit Benders

Industrial installations of rigid metal conduit have routinely presented electricians with jobs of great proportions; however, with the hydraulic equipment in use today, this work is easily accomplished. Various attributes of fluid or hydraulic power equipment recommend it to the electrical industry. Hydraulic tools readily increase 100 pounds of applied effort to 200,000 pounds of output. The tools are versatile, light in weight, compact in size, and completely mobile so that one man can carry a hydraulic set capable of moving 50 tons.

In recent years, electrical installations have become larger and more complicated with the result that the electrician is called on to make many large bends in conduit. Hydraulic equipment is used to bend conduit having a diameter larger than 1". Conduit of smaller dimensions is usually bent by a hand bender. The two principal types of benders for large conduit are: (1) a "one-shot" bender which makes a full 90° bend with a single stroke and setting; and (2) a segment bender which requires several smaller, single-stroke stages to complete a 90° bend.

PRESENTING THE LESSON:

Try to have a small hydraulic conduit bender to demonstrate to the class. The student should know how the machine operates as well as its use.

Using the information sheet on rigid metal conduit bending as a guide, the following topics should be discussed:
1. Radius of bend
2. Principles of precision bending
3. Concentric bending
4. General purpose bending
5. Bending the angle

To review important topics on rigid metal conduit wiring referred to in American Electricians' Handbook.

APPLICATION:

Have the students complete the answers to the questions on the assignment sheets.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME ______________________ LESSON NO. A-25

DATE ______________________ WORKSHEET A-25

RIGID METAL CONDUIT & INTERMEDIATE METAL CONDUIT

1. Rigid metal conduit may be used under all atmospheric conditions, except: (C)

   (a) when raining
   (b) near expressways
   [✓ (c) severe corrosive areas]
   (d) where TW wire is used

2. The use of dissimilar metals in contact in a rigid raceway system shall be avoided to eliminate the possibility of galvanic action. True/False. TRUE

3. Standard conduit shall be installed at least 18 inches below cinder fill unless installed in a 3 inch minimum concrete envelope. True/False. FALSE (TWO INCHES WOULD BE CORRECT.)

4. In wet locations, entire conduit system shall be installed to prevent WATER from entering conduit.

5. In general the minimum size conduit shall be: (B)

   (a) 1/8 inch [✓ (b) 1/2 inch] (c) 1/4 inch (d) 3/4 inch

6. Two conditions which are exceptions to the minimum size conduit are underplaster extensions and enclosing leads of motors. True/False.

   TRUE

7. Conduit ends shall be reamed to remove: (D)

   (a) paint
   (b) cutting oil
   (c) threads
   [✓ (d) rough edges]

8. Are bushings required on conduit at junction boxes? Yes/No. YES

   If yes, why? TO PROTECT CONDUCTOR FROM ABRASION.

9. Running threads shall not be used to facilitate installation of coupling. True/False. TRUE

10. What is the minimum radius of bend for a 1-inch conduit? (B)

    (a) 5 inches [✓ (b) 6 inches] (c) 4 inches (d) 7 inches

11. The maximum number of bends permitted in one conduit run is four quarter bends or total 360 degrees. true/False. TRUE

12. Standard length of rigid conduit shall be 5 feet. True/False.

FALSE (10 FT. WOULD BE CORRECT.)

13. There are two types of rigid-steel conduit white-galvanized and black enameled. List four of their advantages:

a. FIREPROOF

b. MOISTURE PROOF

c. STRONG MECHANICALLY

d. CHEMICALLY STRONG RESISTS CONCRETE

14. Each conduit run shall terminate in an ACCESSIBLE outlet box.

15. Covers of a junction shall never be CONCEALED.

16. What is the method for fastening conduit to the junction box?

LOCK NUT ON OUTSIDE AND BUSHING ON THE INSIDE.

17. What is a popular field bender? (C) HICKEY

(a) railroad track (c) hickey

(b) between two iron beams (d) hydraulic jack

18. Care must be taken in feeding conductors in conduit to prevent LAPPING or TWISTING.

* 19. Name uses permitted with Intermediate Metal Conduit.

(a) ALL ATMOSPHERIC CONDITIONS

(b) IN CONCRETE OR DIRECT BURIAL

(c) IN HAZARDOUS LOCATIONS

20. What are the minimum and maximum trade sizes of Intermediate Metal Conduit?

(a) Mimimum 1/2"

(b) Maximum 4"

* NOTE: There are no restrictions on the use of I.M.C. now.

21. Match.

a. Bends D&E

b. Supports F

c. Bushings A

d. Splices and taps C

code-sectors

a. 345-15

b. 345-10

c. 345-14

d. 345-11

e. 345-12

22. What is the Standard Lengths (as shipped) of Intermediate Metal Conduit? 10 FEET (345-10)

RIGID METAL CONDUIT BENDING

The art of conduit bending with hydraulic equipment, although still dependent upon the skills of the individual, has been simplified by workable formulas that are easily learned and applied. The principle upon which these formulas are based is safety. The NEC states that bends must be so made that the conduit is not injured and its internal diameter is not effectively reduced. It further states in a table the minimum inside radius of conduit bends.

RADIUS OF BEND

Various factors influence, and in some circumstances determine the radius of a bend. Generally, it should be the longest radius possible. Although the inside radius of a field bend is specified in the National Electrical Code in terms of minimum radius, the specification is intended to insure an undamaged elbow and safe passage for cable. When it comes to actually installing cable in conduit, the relative ease or difficulty of the pull becomes very important to the electrician. Experience quickly teaches you that it is easier to pull cable through a long sweeping elbow than it is through a short, more tightly bent one. Of course, the radius of the bend is the determinant here, for as the radius length increases, the sweep or arc of the bend increases.

From the experience of many electricians, the "rule of thumb" has evolved that a satisfactory elbow can be made in conduit. (1) For LEAD SHEATHED CONDUCTORS by using a radius that is 10 to 12 times the internal diameter of the conduit. (2) Elbows that do not have lead sheaths require a radius equal to 8 to 10 times the conduit's internal diameter.

PRINCIPLES OF PRECISION BENDING

In "one-shot" or "segment bending" of conduit, you must be familiar with the hydraulic benders and how they operate.

Before you can make a precision bend in conduit, you must:

1. Determine the size of conduit to be bent.
2. Determine the radius of the bend.
3. Determine total degrees in the bend.
4. Calculate the developed length.
5. Calculate the gain.
6. Locate the center of bend.
7. Determine the number of bends required.
8. Calculate and mark spacing for bends on the conduit.

All formulas and factor tables are based on measurements to the centerline of conduit.

CONCENTRIC BENDING

Concentric bends are calculated by the same formulas and made by the same processes as those used for 90° bends. Radii and segment bending spaces will differ as each bend recurs in the next-lying run of conduit.

NOTE: Students should observe concentric bending of exposed conduit in several industrial installations.

Whether these bends are to be made in the same or varying sizes of conduit, the radius of the second of two successive concentric bends is equal to the radius of the first plus one-half the sum of their outside diameters plus the width of the spacing between them. Since concentric bends have not only a common center, but also equal separation, sufficient space must be provided between all concentric bends. This will accommodate couplings and straps sized for the largest conduit in the run regardless of their diameters.

GENERAL PURPOSE BENDING

In actual practice, the electrician finds that all hydraulic bending operations do not require an equal degree of precision. While the same mathematical principles are involved, generally, on some jobs it may not be necessary to work with centerline measurements, or to consider the gain or center location of a proposed bend.

However, minimum radius length, which in effect constitutes a safety factor in any conduit installation, and the determination of a bend's developed length cannot be overlooked.

Preliminary Calculations. The electrician's rule, states that ten times the diameter of the conduit as a satisfactory bending radius for the average bending job. The next consideration is to find out the point on the conduit the bend should start. To do this, measure the required rise from the bottom of the conduit, and from this measurement, deduct the length of the radius. The distance remaining is the starting point of the bend, measured from the end of the conduit. Now, with chalk, mark this remaining distance on the conduit as the starting point for the bend. (Illustrate on chalkboard using a 30" radius and 50" rise.)

Now, to calculate the developed length of the bend as before, multiply the radius (30") of the bend by 1.57. Mark this distance on the conduit, measuring from the start of the elbow. Bending gain is calculated by the formula--radius of bend multiplied by gain factor (from table). The overall length equals the leg length plus the developed bend length plus the riser. It is important to find the center or bend and mark it on the conduit for reference.

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BENDING THE ANGLE

Experience becomes the best teacher regardless of the procedure used for bending conduit. Although, the conduit may be divided into two-inch segments and operating instructions are provided for the hydraulic equipment, the special bending accessories may differ from bender to bender. Experience has shown that it is advantageous to reserve two bending spaces, the first and the last, until the other segments are completed and the bend has been checked in place.

It should be noted that to confine the intended bending effect within a given segment, the center of the ram and shoe of the bender should be in line with the center of each bending space (segment). This will provide better overall control and accuracy.

ELECTRICAL METALLIC TUBING

DESIRED RESULTS:

To acquaint the apprentice with the construction and restrictions in the uses of electrical metallic tubing.

MATERIALS:

Samples of electrical metallic tubing

INTRODUCTION:

Electrical metallic tubing (EMT) sometimes called "thin-wall conduit" has a wall thickness less than that of rigid conduit, and it bends more easily. It is connected with compression or indentation-type fittings, since it is too thin to thread. A special tool is used to install indentation fittings.

PRESENTING THE LESSON:

Electrical metallic tubing is installed and has the same use for both exposed and concealed work as rigid conduit except it cannot be used where subject to severe physical damage, or in hazardous locations. When used in wet locations or poured over in concrete, fittings of the type to prevent water entering the conduit shall be used.

Tubing and fittings may be obtained, made of an alloy having corrosion-resisting characteristics. This makes them especially suitable for use in many locations where there are corrosive fumes, or excessive moisture.

No tubing shall be used smaller than 1/2 inch in diameter, electrical trade size, except for under plaster extensions. The maximum size tubing shall be the 4-inch electrical trade size.

Bends in the tubing shall be made so that the tubing will not be injured and that the internal diameter of the tubing will not be effectively reduced. One run of conduit should preferably include not more than three "quarter" bends.

APPLICATION:

Have the students complete the answers to the questions on the assignment sheets for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME____________________ LESSON NO. A-26

DATE____________________ WORKSHEET A-26

ELECTRICAL METALLIC TUBING

1. Electrical metallic tubing is commonly known as: (B) EMT

   (a) NECA [✓ (b) EMT] (c) AWG (d) RHH

2. EMT may be installed exposed or concealed. True/False. TRUE

3. Number of conductors permitted in metallic tubing is found in Article (c) 348 6.

   (a) 450-6 (b) 370-6 [✓ (c) 348-6] (d) 347-6

4. EMT may be installed at a minimum of 18 inches below cinder fill.

5. EMT may be installed in a cinder fill if it has a 2 inch minimum concrete envelope.

6. Maximum size of EMT permitted is: (C) 4 INCH

   (a) 1/4 inch (b) 2 inch [✓ (c) 4 inch] (d) 6 inch

7. If EMT is installed in wet locations, raintight connectors shall not be used. True/False. TRUE.

8. Concrete tight couplings shall be used on EMT installed in concrete to prevent moisture entering raceway. True/False. TRUE

9. Bends in EMT shall not exceed 4 quarter bends or equivalent 360 degrees between outlets or fittings.

10. EMT shall not be used on electrical systems exceeding (A) 600 VOLTS.

    [✓ (a) 600 Volts] (c) 120 Volts
    (b) 300 Volts (d) 208 Volts

11. In wet locations, EMT shall be mounted with air space between it and supporting surface at least (D) 1/4 INCH.

    (a) 1/2 inch (b) 1/2 mile (c) 23 meters [✓ (d) 1/4 inch]

12. The minimum size EMT allowable is: (c) 1/2 inch

(a) 1/4 inch (b) 1/8 inch [✓ (c) 1/2 inch] (d) 1/2 meter

13. Standard length for conduit is 10 ft. but EMT is 5 ft. True/False.
FALSE

RIGID NONMETALLIC CONDUIT AND FLEXIBLE METAL CONDUIT

DESIRED RESULTS:

To acquaint the apprentice with the construction and restrictions in the uses of flexible metal conduit and rigid nonmetallic conduit.

MATERIALS:

Samples of the conduit.

INTRODUCTION:

Flexible metal conduit is used in difficult places requiring a number of irregular bends or where flexibility is required, such as connecting a motor to rigid conduit, not exceeding 24 inches in length.

Flexible metal conduit is used and installed according to the rules and practices for installation and use of armored cable. It is installed and conductors are pulled into it in the same way conductors are installed in rigid conduit. The size of flexible conduit is determined by the inside diameter.

Flexible nonmetallic conduit is used for both low voltage and high voltage wiring within the limitations of the N. E. Code. Because of its resistance to corrosion and high moisture and vapor areas, it is becoming a widely used raceway material.

PRESENTING THE LESSON:

Installations of flexible metal conduit shall comply with the provisions of the code listed in paragraph 349-3 of the Code.

Flexible metal conduit shall not be used in:
1. Wet locations, unless lead-covered type
2. Hoistways, except as provided in Section 620-21
3. Storage-battery rooms
4. Anv hazardous location except permitted in Sections 502-4 and 503-3
5. Where rubber-covered conductors are exposed to oil, gasoline, etc.

MINIMUN SIZE - No flexible metal conduit less than one-half inch electrical trade size shall be used except as permitted in Section 349-10

Straps or other means of securing the conduit in place should be spaced much closer together for flexible conduit than is necessary for rigid conduit. Every bend should be rigidly secured so that it will not be deformed when the wires are being pulled in, thus causing the wires to bind.

LIQUIDTIGHT FLEXIBLE METAL CONDUIT - This conduit is similar in construction to the flexible metal conduit but is covered with an outer sheath of material to make a liquidtight jacket.

Connectors and grounding bushings are available for terminating the conduit and providing effective grounding connections. It is used in the wiring of machine tools, motors, or portable equipment where flexibility of connection is required.

Paragraph 351 -4 lists the conditions under which liquidtight flexible metal conduit shall not be used .
1. Where it is subject to mechanical injury
2. Where it is in contact with rapidly moving parts
3. Where the temperature is above its approved use.
4. In any hazardous location.

The maximum sizes of the conduit and conductors to be installed are listed in Article 351, paragraphs 351.5 and 351-6

Installations of rigid nonmetallic conduit shall comply with the provisions of the Code listed in Article 347.

Because of the many types of nonmetallic conduit available, the instructor should spend some time in acquainting the student with these types:

(1) Fiber
(2) Asbestos
(3) Cement
(4) Soapstone
(5) Rigid polyvinyl chloride
(6) High density polyethylene

Since each material has its own unique methods of installation and assembly, the instructor may wish to have an outside materials supplier have a demonstration of the various materials.

APPLICATION:

Have the students complete the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers to the questions and return the sheets to the students for correction and placing in their notebooks.

NAME______________________ LESSON NO. A-27

DATE______________________ WORKSHEET A-27

RIGID NON-METALLIC CONDUIT AND FLEXIBLE METAL CONDUIT

1. Clips and straps may be used to support flexible metal conduit. True/False. TRUE

2. Supports from outlets or fittings for flexible metal conduit shall be located a maximum of (A) 12 INCHES.

   [✓ (a) 12 inches] (b) 6 inches (c) 3 inches (d) 2 inches

3. Supports for flexible metal conduit shall be located a maximum of 4 1/2 feet on centers.

4. List three conditions where supports for flexible metal conduit are not required:

   a. LENGTH NOT MORE THAN 36" AT TERMINALS WHERE FLEXIBILITY IS NECESSARY

   b. ACCESSIBLE ATTICS OR ROOF SPACES

   c. UNDER JOISTS WHERE SUPPORTED IN JOIST

5. Minimum radius bend for flexible metal conduit shall be 5 times conduit diameter. True/False. TRUE

6. Installation of flexible metal conduit is harder and slower than installation of rigid conduit. True/False. FALSE

7. Flexible metal conduit must be CONTINUOUS from outlet to outlet.

8. The minimum size of flexible conduit permitted is (A) 1/2 INCH.

   [✓ (a) 1/2 inch] (b) 1 inch (c) 3 inches (d) 3/4 inch

9. What is the difference between flexible conduit and liquid tight flexible conduit?

   LIQUID TIGHT HAS AN OUTER JACKET

10. Boxes and fittings for rigid non-metallic conduit is found in Article 370.

    (a) 347 [✓ (b) 370] (c) 348 (d) 450

11. Rigid non-metallic conduit not encased in concrete shall be installed a minimum of 18 inches below grade.

12. Supports of rigid non-metallic conduit is found in Table 347-8.

13. There are five areas which are not approved for using rigid non-metallic conduit. Which Article covers this? ARTICLE 347-3.

14. Article 347-2 covers areas which are approved for using rigid non-metallic conduit.

15. The maximum voltage for rigid non-metallic conduit not encased in concrete is 600 volts. If encased in 2 inches of concrete, can this voltage be exceeded? Yes/No YES. Give the Code Section for your answer. 347-2 (B)

16. Is an equipment grounding conductor always required when nonmetallic conduit is used? Yes/No NO. Give the N. E. Code Article to prove your answer. 347-4

17. Can field bends and offsets be made in rigid nonmetallic conduit? Yes/No YES. Give the N. E. Code reference to prove your answer. 347-13

18. Is all rigid nonmetallic conduit suitable for installations above grade and in sunlight? Yes/No NO. Give the N. E. Code Section to prove your answer. 347-1

OUTLETS, SWITCH AND JUNCTION BOXES, AND FITTINGS

DESIRED RESULTS:

1. To acquaint the apprentice with outlet and junction boxes and fittings used in electrical wiring.
2. To study carefully the uses of various types of outlet and switch boxes, and their accessories.

MATERIALS:

Samples of various boxes and switches
Catalogs

PRESENTING THE LESSON:

Demonstrate the various boxes, giving the correct names, shapes, uses, and how to attach the wiring. Show how the boxes for interior wiring are classified. Describe the use of nonmetallic boxes and the straight-through junction boxes. Discuss outlet switches and their use.

APPLICATION:

The student should complete the worksheet assignment for this lesson.

CHECK AND FOLLOW-UP:

Check the assignment sheets and return them for correction and placing in notebook. Discuss common errors made on the worksheets.

NAME ______________________ LESSON NO. A-28

DATE ______________________ WORKSHEET A-28

OUTLETS, SWITCH AND JUNCTION BOXES AND FITTINGS

1. Outlet boxes used for interior wiring are classified into the following groups:

   (a) OUTLET BOX
   (b) UTILITY BOX
   (c) SECTIONAL SWITCH BOX
   (d) FLOOR BOX

2. What are the major shapes of outlet boxes?

   (a) ROUND
   (b) OCTAGONAL
   (c) SQUARE
   (d) OBLONG

3. Box accessories consist of:

   (a) SUPPORT BRACKETS OR EARS
   (b) STUDS
   (c) CABLE CLAMPS
   (d) COVERS

4. Can non-metallic boxes be used for metallic conduit systems? Yes/No. NO. Article 370-3 in the Code Book contains this ruling.

5. List the most important items which determine which type outlet or switch box must be used:

   (a) SPECIFICATIONS
   (b) LOCATION IT IS USED IN
   (c) SPACE FOR CONDUCTORS
   (d) SPACE FOR FITTINGS AND DEVICES

6. Can a standard flush receptacle box be used as a floor box? Yes/No. YES. Article 370-17 in the Code Book contains this ruling.

7. Study carefully the various types of outlet and switch boxes and their accessories as illustrated in the American Electrician's Handbook, and be prepared to discuss them.

8. What determines the length of a straight-thru junction box? Circle the right answer. (B) SIZE OF CONDUIT

   (a) Number of wires.
   (b) Size of conduit.
   (c) Number of conduits.
   (d) Number of joints to be made in the box.

9. How deep and wide must this straight-thru junction box be?
SIZED LARGE ENOUGH TO ALLOW THE LOCKNUT AND BUSHING TO BE RUN ONTO THE CONDUIT.

10. What determines the length of an angle or U-pull junction box? Circle the right answers. (B) SIZE OF CONDUIT

    (a) Number of wires.
    (b) Size of conduit.
    (c) Number of conduits.
    (d) Number of joints to be made in the box.

11. Would the answer to question #9 be the same for the angle or U-pull junction box? Yes/No. YES .

12. If a straight-thru junction box is installed in the same conduit run, The straight-thru junction box would be (A) . (Circle one)

    [✓ (a) Longer]
    (b) Shorter
    (c) Same length thru the angle pull junction box.

13. Would the size of the junction boxes in the question above change if the conduit run were paralleled into each of these boxes? Yes/No. YES .

14. Mark the items for each junction box which are changed as a result of paralleling the conduit run.

Straight-Thru	**Angle Pull**
__________ length	✓ length
✓ width	✓ width
__________ depth	__________ depth
__________ stay the same size	__________ stay the same size

15. Boxes over 100 cubic inches in size are classified as a CABINET or CUT OUT box.

16. Can splices & taps be made in a L.B. Conduit Body? Yes/No.
ARTICLE 370-6 (c)

AUXILIARY GUTTERS AND WIREWAYS

DESIRED RESULTS:

1. To learn the purposes and correct use of auxiliary gutters and wireways.
2. To learn the restrictions as to the size and number of conductors allowed in the various auxiliary gutters and wireways.

PRESENTING THE LESSON:

Using the National Electrical Code (latest edition) and other references, discuss the use and installation of auxiliary gutters and wireways. Call attention to the various restrictions and rules to follow in making the installations.

APPLICATION:

The students should answer all questions on the worksheets for this lesson.

CHECKING AND FOLLOW-UP:

After the worksheets have been checked for errors, return the papers for corrections and discussion of errors.

NAME ____________________ LESSON NO. A-29

DATE ____________________ WORKSHEET A-29

AUXILIARY GUTTERS AND WIREWAYS

1. Wireways and auxiliary gutters are examples of electrical raceways. True/False. TRUE.

2. Auxiliary gutters are used to supplement wiring spaces at meter, distribution and switchboard centers. True/False. TRUE.

3. Wireways are used to house and protect wires and cables. True/False. TRUE.

4. What is the main difference between an auxiliary gutter and a wireway? THE AUXILIARY GUTTER MAY ENCLOSE CONDUCTORS OR BUS BARS AND A WIREWAY MAY ENCLOSE ONLY CONDUCTORS..

5. Can auxiliary gutters and wireways be used outdoors? Yes/No. YES If the answer is "yes," under what conditions may it be used? THEY SHALL BE OF APPROVED RAIN TIGHT CONSTRUCTION..

6. Can splices and taps be made in auxiliary gutters and wireways? Yes/No. If the answer is "yes," under what conditions may they be made? INSULATED BY APPROVED METHODS, ARE ACCESSIBLE AND THE CONDUCTOR, SPLICE AND TAP DOES NOT EXCEED 75% OF THE CROSS-SECTIONAL AREA OF THE WIREWAY OR GUTTER..

7. The Code limits the number of current carrying conductors to 30 in both auxiliary gutters and wireways. True/False. FALSE.

8. If the answer to the question above is "false," circle the one which is not limited to 30 current carrying conductors. (C) NEITHER

   (a) Auxiliary Gutters (b) Wireway [✓ (c) Neither]

9. Does Note # 8 to Tables 310-16 through 310-19 apply to auxiliary gutters and wireways? [✓ Yes]/No. EXCEPT # 3

10. If the answer to the above question is "no," circle the one to which it does apply. (C) BOTH

    (a) Auxiliary Gutters (b) Wireways [✓ (c) Both]

11. Does a 20% fill capacity limit apply to auxiliary gutters and wireways? Yes/No. YES.

12. If the answer to the above question is "yes" or "no," circle the one to which the 20% fill is applicable

(a) Auxiliary Gutter (b) Wireway [✓ (c) Both]

13. Can aluminum conductors and bus bars be installed in auxiliary gutters? Yes/No. YES .

14. Can aluminum conductors be installed in wireways? Yes/No. YES .

15. Can an auxiliary gutter extend more than 30' beyond the equipment which it supplements? Yes/No. YES .

16. If the answer is "yes," what provisions must be made?
ARTICLE 362 ("WIREWAYS") AND ARTICLE 364 ("BUSWAYS") .
If the answer is "no," you get a free question.

17. Can conductors be installed before the auxiliary gutter or wireway installation is completely installed? Yes/No. No .

18. Name six (6) methods by which extensions can be made from a wireway to other items of electrical equipment.

(a) RIGID CONDUIT
(b) E. M. T.
(c) SURFACE METAL RACEWAYS
(d) FLEXIBLE METAL CONDUIT
(e) METAL-CLAD CABLE
(f) INTERMEDIATE METAL CONDUIT

19. Auxiliary gutters may not enclose switches, over-current protective devices or appliances. Does Code Section 374-1 apply to these items? Yes/No. YES .

20. Is an end cap required when a wireway butts against a 4 inch thick concrete wall? Yes/No. YES .

CABINETS AND CUTOUT BOXES

DESIRED RESULTS:

1. To learn the purposes and the installation regulations for cabinets and cutout boxes.
2. To review the construction specifications for cabinets and boxes.

PRESENTING THE LESSON:

Discuss the purposes and installation regulations for cabinets and boxes. Using the N. E. Code, review the construction specifications of cabinets and boxes. Discuss how the conductors entering cabinets and cutout boxes are protected.

Review the specifications for spacing within cabinets and cutout boxes. Explain the use of conduit bushings and locknuts on cabinets and cutout boxes.

APPLICATION:

The student should answer the questions on the worksheet.

CHECKING AND FOLLOW-UP:

Check the questions on the worksheet; discuss those answers that are incorrect and make corrections.

DATE______________________ WORKSHEET A-30

CABINETS AND CUTOUT BOXES

1. Where in the Code can you find the difference between a cabinet and/or cutout box? ARTICLE 100.

2. The description of a cabinet describes a panelboard enclosure. True/False FALSE.

3. The description of a cutout box describes an enclosure in which control or metering components may be mounted. True/False TRUE.

4. Cabinets and cutout boxes can be installed in the following locations. Check the approved ones.

   (a) ✓ Hazardous locations
   (b) ✓ Outdoors, in the weather
   (c) ✓ Subject to "hose-downs" as in a dairy
   (d) ✓ In dusty locations
   (e) ✓ Indoors, in dry locations

5. Is a cabinet or cutout box of non-conductive material approved by the Code? Yes/No YES.

6. Why are the dimensions for flush mounting in a combustible wall so critical? TO LESSEN THE DANGER OF FIRE SHOULD AN ARC OCCUR.

7. Only rigid conduit, EMT, and flexible conduit may be run to a cabinet or cutout box. True/False FALSE.

8. Can unused knockouts be left open in the bottom of a cabinet or cutout box for ventilation? Yes/[✓ No] Give the Code section and paragraph rule for your answer. 373-4.

9. A single 500 MCM conductor per phase is loop fed through one panel with double barrell lugs to another panel. What is the minimum width gutter allowed? 8 INCHES.

10. How is the gutter width distance measured?

    IN A STRAIGHT LINE FROM THE END OF THE LUG TO THE WALL OR BARRIERS.

11. Can an insulating sleeve be used with a metal bushing on a #4 AWG conduit circuit entering a cabinet or cutout box? Yes/No YES.

12. How many locknuts are required? 1. Where must it/they be placed? ON THE OUTSIDE OF THE CABINET OR CUTOUT BOX.

13. Can a fully insulated bushing be used on #4 AWG conduit circuit entering a cabinet or cutout box? Yes/No YES.

14. How many locknuts are required? 2. Where must it/they be located? ONE ON THE INSIDE AND ONE ON THE OUTSIDE OF THE ENCLOSURE.

STORAGE BATTERIES

DESIRED RESULTS:

1. To acquaint the student with the construction and operation of storage cells.
2. To acquaint the student with the chemical properties of different types of cells.
3. To teach the student to understand electrolysis, and other instances of electrochemical action.

MATERIALS AND EQUIPMENT:

1. A cutaway model of storage cell
2. Supplies to make a storage cell

INTRODUCING THE LESSON:

The study of batteries could be a course in itself, but in this lesson the student should become acquainted with the chemical properties of several types of cells. One of the major problems involved in electrical systems, depending on storage cells for part-time operation, is the proper battery care and maintenance. The facts explained in this lesson should be thoroughly understood by people who maintain this type of equipment.

PRESENTING THE LESSON:

Point out:

1. That cells, such as dry cells, that cannot be charged are called "primary cells" to distinguish them from those that can be recharged, known as "secondary cells" or the storage battery.
2. A storage cell does not store electrical energy; it stores chemical energy and then changes the chemical energy into electrical energy as needed.
3. When the chemical energy has all been changed to electrical energy, it can be restored only by sending a current through the cell.
4. There are two main types of storage cells in use. The "lead acid" used on all motor-driven vehicles and the "Edison cell" which is extremely rugged but has low cell voltage. The Edison cells are not as efficient as lead acid cells, as they return only 60 to 65 percent of the charging energy.

PRESENTING THE LESSON: continued

5. Nickel-cedmium (alkali type) batteries, and other electrochemical types are becoming common-place items. They supply power for radios, emergency lighting units, signal systems (fire alarm systems) and computor back-up supply.

6. Electrolytic cells - article 668 - should be mentioned briefly. The apprentice should be aware of manufacturing processes requiring electrical power and the code requirements covering this type equipment.

APPLICATION:

Have the students work and hand in assignment sheet. Give individual help where needed.

CHECKING AND FOLLOW-UP:

Check assignment sheets against answer sheets and return to the students for correction and placing in workbook.

NAME ______________________ LESSON NO. A-31

DATE ______________________ WORKSHEET A-31

STORAGE BATTERIES

1. Match the following letter that corresponds with the number.

B 1. Lead Acid Type Battery — a. 1.2 volts per cell

A 2. Alkali Type Battery — b. 2.0 volts per cell

2. List two methods of supporting lead-acid batteries:

a. GLASS b. PORCELAIN INSULATORS

3. List two materials used in construction of racks:

a. WOOD OR FIBERGLASS b. METAL

4. An electric battery is a device for producing a voltage by: CHEMICAL MEANS

a. high voltage switch c. chemical means

b. copper conductors d. dissimilar rubber contacts

5. A battery may consist of a single cell or combination of cells. True/False. TRUE

6. List two classifications of batteries:

a. PRIMARY b. SECONDARY

7. Secondary batteries may be charged or discharged and are commonly called STORAGE BATTERY.

8. Primary batteries can be used to discharge only. True/False. TRUE

9. List three fundamental materials for battery construction:

a. LEAD ACID c. NICKEL CADMIUM

b. NICKEL-IRON-AKALINE

10. The charging rate is expressed in (A) AMPERES.

[✓ (a) amperes] (b) volts (c) watts (d) ohms

11. Storage batteries are rated in ampere hours. True/False. TRUE

12. The maximum temperature of a lead-acid battery should be (B) 110°F.

(a) 120° F (b) 110° F (c) 50° C. (d) 212° F

13. Batteries must be charged with direct current and the POSITIVE pole of the charging source must be connected to positive terminal of the battery.

14. Storage batteries require adding WATER only.

15. Study drawing of a primary cell.

16. Study drawing of a dry cell.

FUSES AND OVERCURRENT PROTECTIVE DEVICES

DESIRED RESULTS:

1. To learn that in electrical work every circuit must be provided with overcurrent protection.
2. To understand the National Electrical Code standard fuse ratings and the sizes required for protection of certain devices.

MATERIALS AND EQUIPMENT:

1. Sample fuses of different types: plug, cartridge, knife-blade contact renewable fuse, etc.
2. Edison-type fuse, time-lag fuse (if available).
3. Circuit breakers

INTRODUCTION:

In electrical work every circuit must be provided with overcurrent protection. It may be a 13,200 volt transmission line carrying 200 amperes, or it may be 110 volt lighting circuit with a load of 10 amperes. Each must have some form of protective device for the possible overload of current for the protection of both circuits and apparatus.

In this lesson we are primarily concerned with the simpler circuits requiring the common types of overcurrent protective devices, such as, the plug fuses circuit breakers and the cartridge fuses. As we advance in the program, the more complicated protective devices will be investigated.

PRESENTING THE LESSON:

The need for the use of protectvie devices as fuses has beeen discussed. You have learned that excessive current may seriously damage electrical equipment - motors, instruments, radio receivers, etc. Fuses are cheap--other equipment much more expensive. When the fuse which is connected in series with the equipment is blown, the circuit will open before the excessive current damages the equipment.

Demonstrate sample fuses to the class: glass cartridge fuses, solid cartridge fuses, screw-plug fuses, and circuit breakers.

It is important that you always use fuses or circuit breakers with the proper current rating. The rating should be slightly higher than the greatest current you expect in the circuit. Example: Since the range of an ammeter is 0 to 1 ampere, a 1.5 amp fuse should be used to protect the equipment. In protecting equipment, to use fuses with too low current rating will result in unnecessary blowouts, while one with too high current rating may allow dangerously high currents to pass.

Precautions: Fuses are used for protection. Do not jumper out a fuse. Do not increase the size of a fuse unless and until you are sure it is the right thing to do.

NOTE: The Bussman Fuse Company will be glad to put on a demonstration for this lesson. Contact their representative and arrange for him to be present. In the event that a representative of the above company is not available, try to contact a representative of another company or a specialist in this field.

APPLICATION:

Give the class time to answer the questions concerning "overcurrent protection" on the assignment sheet.

CHECKING AND FOLLOW-UP:

Correct the assignment sheets, discuss the results, and have the students place them in their workbooks.

NAME ____________________ LESSON NO. A-32

DATE ____________________ WORKSHEET A-32

FUSES AND OVERCURRENT PROTECTIVE DEVICES

1. Fuses or overcurrent devices will open circuit to prevent EXCESSIVE currents from accidentally flowing through equipment and burning it up.

2. When two points in a circuit having low resistance are accidentally connected, it is called a (A) SHORT CIRCUIT.

   [✓ (a) short circuit] (c) POW

   (b) run (d) sparkling circuit

3. Fuses are rated in AMPERES.

4. A fuse that permits high current in a circuit for approximately 20 to 30 seconds is a TIME DELAY.

   (a) bad fuse (c) good fuse

   [✓ (b) time delay] (d) plug in type

5. Fuses are metal resistors with very low resistance. True/False.
   TRUE

6. Fuses are connected in parallel with equipment. True/False.
   FALSE

7. List three types of fuses:

   (a) PLUG TYPE (c) KNIFE BLADE

   (b) CARTRIDGE TYPE

8. Fuses with too low a rating will result in unnecessary FALSE - BLOWING.

9. What percent overload is a fuse capable of carrying before blowing?
   10%

   [✓ (a) 10%] (c) 45%

   (b) 25% (d) 125%

10. Plug fuse will open the circuit in 3 seconds at 200 percent load.

11. Match the following letter to correspond with the matching number:

B	1. Plug Fuse	a. maximum racing 6000 ampere
C	2. Cartridge fuse at 250 volts	b. maximum rating 60 ampere
A	3. Silver sand	c. maximum rating 600 ampere

12. Dual element cartridge fuses contain a thermal element and a fuse link. True/False. TRUE

13. Plug fuses shall not be rated over 125 volts.

14. The 250 volt cartridge fuse is permitted on LOWER voltages.

15. All equipment shall be protected against OVERCURRENT.

16. In residential occupancies all overcurrent protective devices with maximum rating of 20 amperes shall be the time delay type. True/False. FALSE

17. What percent shall conductors be protected to prevent currents above allowable current carrying capacity of the conductor?

(a) 140%

(b) 110%

(c) 125%

(d) 100%

18. Temperature will affect the operation of thermally controlled circuit breakers and must be considered in the application and sizing. True/False. TRUE

19. Plug fuseholders screw shell shall be connected to the LOAD side of the circuit.

20. Overcurrent devices shall be installed in each UNGROUNDED conductor.

21. Overcurrent devices shall be located where conductors receive its supply. True/False. TRUE

22. Overcurrent devices shall be in READILY ACCESSIBLE locations.

23. Overcurrent devices shall not be EXPOSED to physical damage.

24. Circuit breakers shall be capable of being manually opened or closed. True/False. TRUE

25. Ampere rating does not have to be visible after installation of circuit breaker. True/False. FALSE

26. Fuses shall be connected on the LOAD side of the disconnect switch.

27. Overcurrent devices is not required on a feeder tap to a panelboard located within 10 feet of feeder.

28. Motor circuit overcurrent protective devices may be rated from 115 percent to 125 percent of motor full-load current.

29. Two types of overcurrent protective devices have been added to the N.E. Code for motor circuit protection. They are:

(a) MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

(b) TIME-LIMIT CIRUCIT BREAKER

30. Can fuses be installed in parallel. Yes/[✓ No] NO.
Give N.E. Code Section. 240-8

31. Can circuit breakers be installed in parallel. Yes/No YES
240-8

32. What four items of information are required on each fuse or circuit breaker?

(a) AMPERE RATING

(b) VOLTAGE RATING

(c) INTERRUPTING RATING

(d) NAME OF MANUFACTURER

Alternate Answer: CURRENT - LIMITING IF APPLICABLE

LIGHTING FUNDAMENTALS

DESIRED RESULTS:

1. To help the student understand what light is and how it is produced.
2. To help prepare the student to utilize the experience he receives on the job in relation to lighting.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Samples of lamps
2. Light meter
3. Pictures of lamps with parts identified

INTRODUCTION:

The electrician should have a basic understanding of the nature and character of light. You may not be asked to design a large lighting system but you will spend much of your working time installing equipment. It will help you to know the basic things about light--what light is and how it is produced. Intensive study of applied light and its influence upon man has developed only recently. We have witnessed the development of several new light sources and the demand for safe equipment and higher illumination levels for industrial and commercial buildings.

There are four separate divisions in the development of a lighting system that must be considered.
1. Design of the lighting equipment.
2. Manufacture of the lighting fixture.
3. Design of the lighting layout and system.
4. Actual installation of the equipment.

PRESENTING THE LESSON:

1. Discuss and define the following terms:
    a. Light
    b. Foot-candle
    c. Watt
    d. Lumen
    e. Reflected light
    f. Refraction
2. List the three primary colors.
3. Discuss three different classes of glare.
4. Explain differences in high pressure sodium and low pressure sodium lighting.

5. Describe incandescent, fluorescent, high intensity discharge lamps, and low pressure sodium lamps.
6. Demonstrate the light meter by showing how the light reading varies in different parts of the room.

APPLICATION:

Have the students answer the questions on the worksheet, A-33.

CHECKING AND FOLLOW-UP:

Correct the answers and discuss any questions that the students may ask concerning the lesson.

NAME________________________ LESSON NO. A-33

DATE________________________ WORKSHEET A-33

LIGHTING FUNDAMENTALS

1. Light may be defined as RADIANT energy of those wave lengths to which the human eye is sensitive.

2. The color of objects is due to the color of the light that the object reflects or transmits to our eyes. True/False TRUE.

3. Match the correct word or number with the statement which best describes it:

(a) Visual comfort	D	1.	The speed of light.
(b) Brightness	C	2.	Light "out of place" causing eye discomfort or interference with vision.
(c) Glare	E	3.	The unit of illumination or light density equal to one lumen per square foot.
(d) 186,000 miles second	B	4.	An expression related to the degree of brilliancy of any surface emitting or reflecting light.
(e) Foot candles	A	5.	Freedom from direct or reflected glare.
(f) Light bulb	F	6.	A device for converting electrical energy into visible radiant energy.

4. Rate the three basic light sources as to their efficiency in lumen per watt output: (1st, 2nd, 3rd)

1 [✓ 2] 3 Fluorescent

1 2 [✓ 3] Incandescent

[✓ 1] 2 3 High Intensity Discharge

5. High intensity discharge lamps can be separated into the following major categories:

(a) MERCURY (b) METAL HALIDE (c) HIGH PRESSURE SODIUM

6. Discuss the construction of the following types of lamps:

(a) Incandescent)
(b) Fluorescent) See illustrations
(c) High Intensity Discharge)

7. All lamps have similar component parts. List below the five (5) most common parts of a lamp.

(a) BASE
(b) BULB
(c) FILAMENT (ELECTRODE)
(d) GAS
(e) COATING

8. Rate the three light sources as "Good," "Fair," or "Poor" for the following

	Incandescent	Fluorescent	High Intensity Discharge
Lumen Output	POOR	FAIR	GOOD
Lamp Life	POOR	FAIR	GOOD
Operating Temperature	GOOD	FAIR	GOOD
Voltage	GOOD	POOR	POOR
Frequency	GOOD	GOOD	GOOD
Operation on DC	GOOD	FAIR	—
Radio Interference	—	FAIR	FAIR
Ballast Noise	—	FAIR	POOR

9. Light output from lamps is measured in LUMENS.

10. The efficiency of a lamp is measured in "lumens per watt" output. True/False TRUE.

11. Low pressure sodium lamps give a color-balanced light similiar to daylight FALSE True/False.

I.E.S. RECOMMENDED FOOT-CANDLE LEVELS*

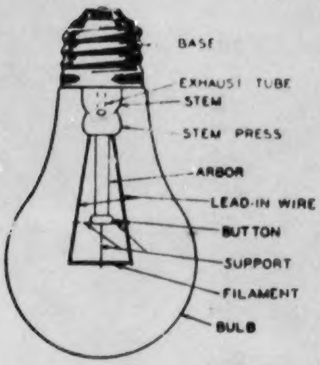
Art Galleries	
General	30
On paintings (supplemental)	30
On statuary, etc.	100
Social activities	5
Banks	
Lobby general	50
Lobby writing areas	70
Tellers' stations	150
Posting and key punch	150
Churches, Synagogues	
Altar, ark, reredos	100
Choir	30
Pulpit, rostrum (supplemental illumination)	50
Main worship area	15-30
Court Rooms	
Seating area	30
Court activity area	70
Depots, Terminals	
Waiting room	30
Ticket offices	100
Rest rooms and smoking room	30
Baggage checking	50
Concourse	10
Platforms	20
Hospitals	
Corridor	
General	10
Operating and delivery suites and laboratories	20
Lobby	30
Lounge rooms	30
Nurses' station	
General	20
Desk and charts	50
Medical room counter	100
Nurses' workroom	30
Patients' rooms	
General	10
Reading	30
Solariums	20
Waiting room	
General	15
Reading	30

Hotels	
Bathrooms, bedrooms, lobby	
Mirror	30
General	10
Corridors, stairs	20
Entrance foyer	30
Front office	50
Marquee	
Dark surround	30
Bright surround	50
Library	
Reading room	
Study and notes	70
Ordinary reading	30
Stacks	30
Book repair and binding	50
Cataloging	70
Card files	70
Check-in-out desks	70
Offices	
Cartography, designing, detailed drafting	200
Accounting, auditing, tabulating, bookkeeping business machine operator, rough layout drafting	150
Regular office work	100
Reading or transcribing handwriting in ink or medium pencil on good quality paper, filing	70
Reading high contrast or well-printed material, conferring, interviewing, inactive files, washrooms	30
Restaurants, Lunchrooms, Cafeterias	
Cashier	50
Dining areas	
Leisure type:	
Light environment	30
Subdued environment	15
Quick-service type:	
Bright surroundings	100
Normal surroundings	50

*Based on severity of visual task and time available to comprehend details of task. This table lists only a few recommended levels; complete data available from IES Lighting Handbook.

Food display - twice general levels, but not under	50
Kitchen	70
Schools	
Reading printed material	30
Reading pencil writing	70
Drafting, benchwork chalkboards	150
Stairways	20
Elevators	20
Corridors	20
Washrooms	30
Show Windows	
General	200
Feature	1,000
Stores	
Circulation areas	30
Merchandise areas	
Service	100
Self-service	200
Show Cases	
Service	200
Self-service	500
Feature displays	
Service	500
Self-service	1,000
Stockrooms	30

INFORMATION SHEET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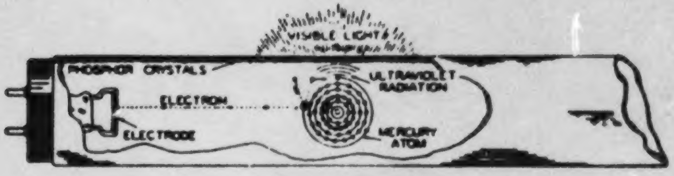
EXHAUST TUBE
STEM
STEM PRESS
ARBOR
LEAD-IN WIRE
BUTTON
SUPPORT
FILAMENT
BULB

INCANDESCENT LAMP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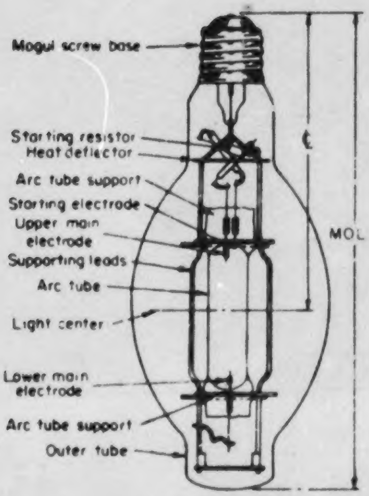
PHOSPHOR CRYSTALS
ULTRAVIOLET RADIATION
ELECTRON
ELECTRODE
MERCURY ATOM

FLUORESCENT LAMP


Mogul screw base
Starting resistor
Heat deflector
Arc tube support
Starting electrode
Upper main electrode
Supporting leads
Arc tube
Light center
Lower main electrode
Arc tube support
Outer tube
LC
MOL

HIGH-INTENSITY-DISCHARGE LAMP

FLUORESCENT LIGHTING

DESIRED RESULTS:

1. To acquaint the student with some of the properties and characteristics of the various types and sizes of fluorescent lamps.
2. To learn the importance of using correct equipment for replacement.

MATERIALS AND EQUIPMENT:

1. A display of different lamps, fixtures, and ballasts.
2. 16mm film projector - film: "The Magic of Fluroescence" - General Electric Company

INTRODUCTION:

This lesson is concerned with the lamp, the ballast, and hints for troubleshooting fluorescent lighting systems. There are several different types of lamps; therefore, the apprentice should know which type he is working with and how it operates. Thus, he should become acquainted with some of the properties and characteristics of the various types of fluorescent lamps.

PRESENTING THE LESSON:

1. Show the film and discuss any questions that may arise.
2. Let the students examine the various samples of lamps.
3. Discussion questions.
    a. Why are fluorescent fixtures gaining in popularity over incandescent fixtures?
    b. For what types of installation would you recommend the use of fluorescent fixtures?
    c. In your opinion, which is the better type of lighting - fluorescent or incandescent?
    d. What is the function of a capacitor?

APPLICATION:

Have the students answer the questions on Worksheet A-34.

CHECKING AND FOLLOW-UP:

Check the answers on the assignment sheets against the answer sheets. Return to learner for placing in workbook.

NAME ______________________________ LESSON NO. A-34

DATE ______________________________ WORKSHEET A-34

FLUORESCENT LIGHTING

1. Every fluorescent fixture has the following component parts: sockets, channel or housing and a ballast. True/False TRUE.

2. The shape and configuration of the base of the lamp determines the type lamp which can be used. True/False TRUE.

3. The voltage rating on the ballast is very critical to the operation of the lamp. True/False TRUE.

4. Ballasts always contain: a transformer, a capacitor, and a reactor. True/False TRUE.

5. What function does the transformer in a ballast perform? STEPS UP THE VOLTAGE TO START THE ARC.

6. What function does the capacitor perform? RAISES THE POWER FACTOR OF THE FIXTURE.

7. What two functions does the reactor perform?
   (1) PROVIDES A HIGH INDUCED STARTING VOLTAGE
   (2) STABILIZES THE OPERATING IMPEDENCE OF THE CIRCUIT

8. The five principal methods of fluorescent lamp operation are:

   (a) PREHEAT A SWITCH
   (b) TRIGGER
   (c) RAPID START
   (d) INSTANT START
   (e) SLIMLINE

9. The most common type ballast found in residences is PREHEAT.

10. The most common type ballast found in commercial and industrial work is RAPID START.

11. Will a fluorescent ballast work without a capacitor? YES.
    Explain. THE CAPACITOR IS USED TO RAISE THE POWER FACTOR ONLY FROM 45-50% TO SOME HIGHER LEVEL FOR MORE ECONOMICAL OPERATION.

12. What is a Class "P" ballast? ONE WHICH HAS BUILT-IN THERMAL PROTECTION TO LIMIT THE BALLAST TEMPERATURE RISE TO 110° C MAXIMUM.

13. What are the six basic types of ballasts used with fluorescent fixtures:
    (a) SIMPLE PREHEAT
    (b) 2 LAMP LEAD-LAG PREHEAT
    (c) 2 LAMP SERIES-SEQUENCE INSTANT START
    (d) 2 LAMP SERIES RAPID START
    (e) SERIES CONNECTED COLD CATHODE LAMPS
    (f) HOT CATHODE RAPID START LAMPS

INFORMATION SHEET **LESSON NO. A-34**

HINTS FOR TROUBLESHOOTING FLUORESCENT LIGHTING SYSTEMS

CONDITION	POSSIBLE CAUSES TO INVESTIGATE
I Lamps won't start	1. Lamp failure 2. Poor lamp-to-lampholder contact 3. Incorrect wiring 4. Low voltage supply 5. Dirty lamps or lamp pins 6. Defective starters* 7. Low or high lamp bulb-wall temperature 8. High humidity 9. Fixture not grounded 10. Improper ballast application 11. Ballast failure
II Short lamp life	1. Improper voltage 2. Improper wiring 3. Poor lamp-to-lampholder contact 4. Extremely short duty cycles (greater than average number of lamp starts per day. Check with lamp manufacturer.) 5. Defective starters* 6. Defective lamps 7. Improper ballast application 8. Defective ballast
III Lamp flicker (Spiraling or swirling effect)	1. New lamps (should be operated 100 hours for proper seasoning) 2. Defective starters* 3. Draftr on lamp bulb from air-conditioning system (lamp too cold) 4. Defective lamps 5. Improper voltage 6. Improper ballast application 7. Defective ballast

*Applies only to preheat (switch-start) circuits

IV	Very slow starting	1. Improper voltage - too low 2. Inadequate lamp-starting-aid strip** (Refer to fixture manufacturer) 3. Poor lamp-to-lampholder contact 4. Defective starter* 5. Defective lamp 6. Improper circuit wiring 7. Improper ballast application 8. High humidity 9. Bulb-wall temperature too low or too high *Applies only to preheat (switch-start) circuits **Applies only to rapid-start and trigger-start circuits
V	Audible ballast "hum"	1. Loose fixture louvers, panels or other parts 2. Insecure ballast mounting 3. Improper ballast selection 4. Defective ballast
VI	Excessive ballast heating (over 90°C ballast case temperature)	1. Improper fixture design or ballast application (Refer to fixture manufacturer) 2. High voltage 3. Improper wiring or installation 4. Defective ballast 5. Poor lamp maintenance (instant-start and preheat 6. Wrong type lamps 7. Wrong number of lamps

HIGH-INTENSITY-DISCHARGE LIGHTING

DESIRED RESULTS:

1. To help the student understand high-intensity-discharge lighting.
2. To gain a knowledge of how the four types of ballasts shown in the worksheets operate.

MATERIALS:

Four samples of ballasts

PRESENTING THE LESSON:

Discuss the four types of ballasts from the material and drawing found on the worksheets for this lesson. What is the basic difference in the three major types of high-intensity-discharge lamps? Give some of the advantages and disadvantages of the five basic types of high-intensity-discharge lamps.

APPLICATION:

Have the students answer the questions on Worksheet A-35.

CHECKING AND FOLLOW-UP:

Correct the answers and discuss questions where the students made common errors.

NAME______________________ LESSON NO. A-35

DATE______________________ WORKSHEET A-35

HIGH-INTENSITY-DISCHARGE LIGHTING

1. What are the four classifications of high-intensity discharge lamps?

(a) MERCURY
(c) HIGH PRESSURE SODIUM
(b) METAL HALIDE
(d) SPECIAL TYPES

2. What is the basic difference in the three major types of high-intensity-discharge lamps? (C) VAPORIZING METAL USED

(a) Shape
(b) Lumen output
(c) Vaporizing metal used
(d) Mounting position

3. What happens to the electrodes as the current changes polarity?

THE ANNODE AND CATHODE CHANGE FUNCTIONS

4. The inner arc tube is usually made of QUARTZ.

5. What is the purpose of the phosphor coating on the bulb?

TO CONVERT THE INVISIBLE ULTRA VIOLET ENERGY INTO VISIBLE LIGHT.

6. What is the purpose of a ballast in a H-I-D circuit?

TO LIMIT THE CURRENT AND KEEPING THE UNIT FROM DESTROYING ITSELF.

7. Is voltage regulation very critical in a H-I-D circuit? YES. Explain. UNDER VOLTAGE REDUCES STARTING RELIABILITY AND OVER VOLTAGE IS LIKELY TO RAISE TEMPERATURES BEYOND SAFE LIMITS.

8. The arc of a H-I-D lamp operating on 60 cycles alternating current is completely extinguished 120 times a second.

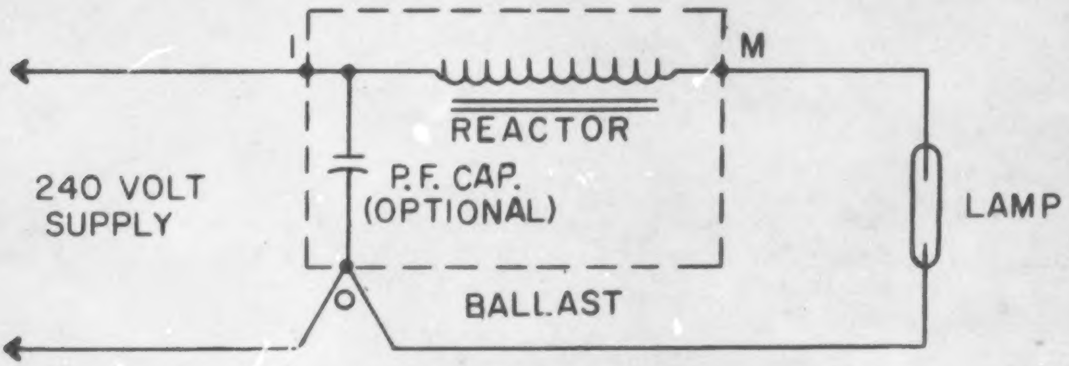
9. Shown on the following information sheets are the five basic types of H-I-D lamp ballasts, giving their advantages and disadvantages.

INFORMATION

HIGH-INTENSITY-DISCHARGE LIGHTING

A. REACTOR BALLAST

The simplest device for ballasting a mercury lamp is the reactor ballast, sometimes referred to as a "choke" coil.



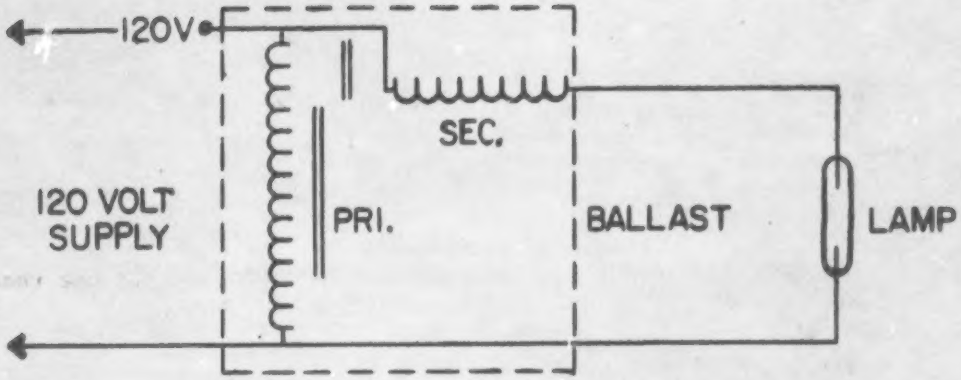
REACTOR BALLAST

The circuit consists of a simple reactor connected in series with the lamp across a power supply. In this case, the ballast is principally a current-limiting device and does not step up or step down the voltage. Therefore the reactor type ballast can only be applied where the supply voltage exceeds the voltage required to start and stabilize the lamp.

Since the reactor is an inductive device, a lagging current will be drawn from the line. If desired, a capacitor can be connected across the line to improve the power factor of the load. The normal power factor of the reactor ballast without a capacitor is about 50%, but if capacitors are used, the power factor can be corrected to 90% or better.

B. LAG BALLAST

Some of the objections of the reactor ballasts are overcome by the lag ballast.



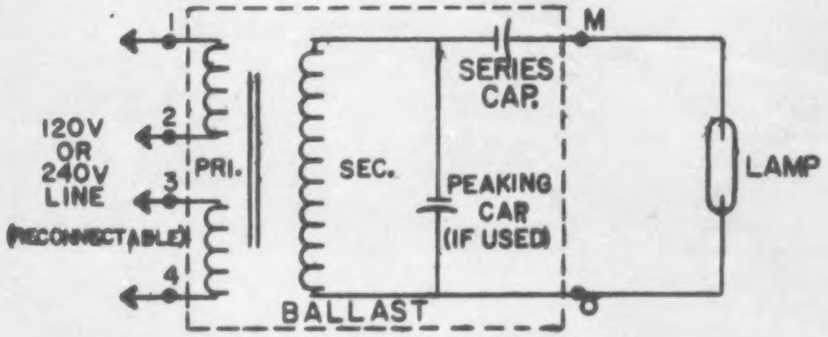
120V
120 VOLT SUPPLY
PRI.
SEC.
BALLAST
LAMP

LAG BALLAST

The lag ballast is basically an auto transformer for stepping up the voltage, plus a reactor for current limiting action. These two functions are usually combined on a single core and coil assembly.

C. REGULATOR BALLAST

By far the most versatile and easiest to apply of all mercury vapor ballasts is the regulator ballast, sometimes referred to as the constant wattage type.

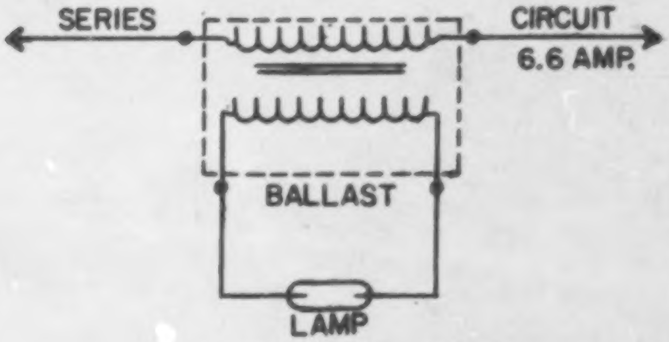


M
1
2
3
4
120V OR 240V LINE
(RECONNECTABLE)
PRI.
SEC.
SERIES CAP.
PEAKING CAP. (IF USED)
BALLAST
LAMP

REGULATOR BALLAST

Its primary and secondary are electrically isolated, but loosely coupled by a magnetic shunt to give the required leakage reactance. The secondary portion of the magnetic circuit is operated in saturation so that a change in primary voltage does not appreciably change the secondary voltage. This constant secondary voltage is then applied across the fixed impedance of capacitors in series with the lamp, and the result is an almost constant wattage on the lamp for wide fluctuations of line voltage. In this manner, the regulator ballast overcomes many of the limitations of the reactor and lag ballasts.

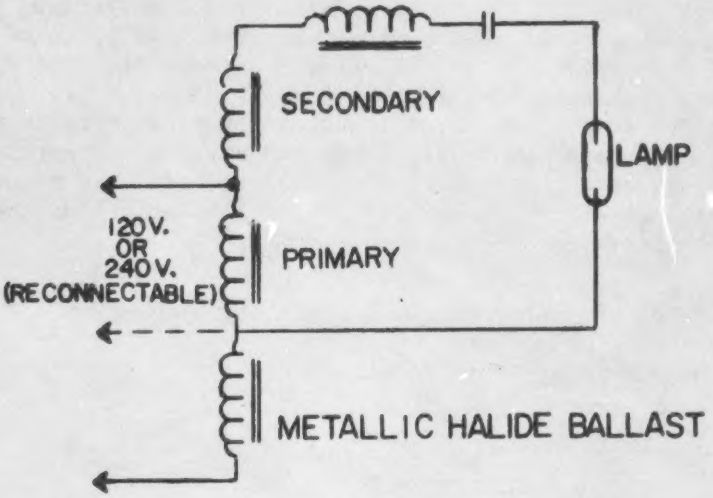
D. SERIES BALLAST



SERIES BALLAST

It consists simply of a current transformer, with the primary connected to the high voltage series circuit and the secondary connected to the lamp. The core has an air gap to limit the open circuit voltage to prevent flashover of the lamp or socket during restarts after temporary outages.

E. METALLIC HALIDE BALLASTS



The lead type ballast has been designed to handle the requirements of the metallic halide lamp, providing the necessary open circuit voltage for starting the lamp and the proper current wave form for operating stability. Bonus-line mercury lamps will also operate on these ballasts. Its operating characteristics are such that it can be described as a hybrid of a lag and regulator ballast or an autotransformer regulator ballast.

The lead ballast can be used on any of the standard primary voltages up to 480 volts and has 95% power factor. Over the allowable ± 10% variation in line volts, lamp watts will vary ± 10%. Starting current is lower than operating current.

Advantages of the Reactor Ballast

1. L[illegible] cost.
2. Lowest losses.
3. Since capacitors are not required for its operation, it may be used in built-in applications which prohibit capacitors because of high temperatures. For example, the accumulation of heat in a ballasted hood from the lamp and ballast exceeds 100°C. Since the rated life of most capacitors is based upon temperatures not over 85°C, it is necessary to utilize a ballast not requiring capacitors.
4. It is relatively insensitive to lamp arc voltage variations resulting from lamp production tolerances.
5. Available in all lamp ratings, from 100 watts to 1500 watts.

Disadvantages of the Reactor Ballast

1. Circuit voltages must be in excess of lamp starting voltage.

2. Inherently poor power factor (45-50%) unless corrected by capacitors.

3. Poor regulation with respect to line voltage changes; a ± 5% change in line voltage will cause a ± 10% change in lamp watts.

4. High starting current, 125-150% of operating currents occur for approximately 3 minutes. This higher current should be factored into the overall system design, especially fusing and line voltage drop.

Advantages of the Lag Ballast

1. Adaptable to the popular 120 volt distribution system.

2. Moderately low cost.

3. Moderately low losses.

4. Since capacitors are not required in its operation, may be used in high temperature locations, so long as coil operating temperature does not exceed 170°C.

Disadvantages of Lag Ballast

1. Low power factor, about 45 to 50% unless corrected by capacitors. Since a power factor corrected lag ballast is comparable in cost to the regulator ballast, applications requiring high power factor are best filled by the more versatile regulator ballasts.

2. Poor regulation of lamp watts, as a ± 5% change in line voltage will cause a ± 10% change in lamp watts - equivalent to the reactor ballast in this respect.

3. Higher starting than operating current, requiring consideration in system design.

In spite of its disadvantages, the lag ballast has been successfully used for multiple streetlighting for many years. The main reason for this has been the fact that it will operate a mercury vapor lamp from a 120 volt source, whereas a reactor ballast is not capable of this type of operation. It is a capable performer at relatively low cost, especially on well regulated distribution systems. Ratings of available lag ballasts are usually limited to 400 watts.

Advantages of the Regulator Ballast

1. Excellent regulation of lamp watts with line voltage variation a ± 13% change in line voltage will yield only 4% total watts variation over the range for 100 thru 400 watt lamps and 8% lamp watts change for 700 and 1000 watt ballasts.

2. Inherent high power factor, usually 95% or better throughout the primary voltage range.

3. Can be built to provide sufficient open circuit voltage for any lamp and any line voltage.

4. It has starting current less than operating current.

Disadvantages of Regulator Ballast

1. Higher cost.

2. Higher losses.

In the series circuit, the ballast performs the following important functions:

1. Isolates the lamp circuit from the high voltage series circuit so that relamping can be done in safety even while the circuit is in operation.

2. Provides the necessary open circuit voltage for cold starting of lamps.

3. Transforms the series circuit current to the proper lamp current.

4. Automatically bypasses burnt out lamps without circuit interruptions without the necessity of film cutouts.

BLUEPRINT READING

DESIRED RESULTS:

1. To learn how to read electrical prints.
2. To learn that specifications are the "who, what, and when" of a contract.
3. To determine the building trades involved in a contract.
4. To learn the electrical symbols and other symbols involved in a print.
5. To review how to read the various scales.

MATERIALS:

Job prints for electrical installations

PRESENTING THE LESSON:

Prepare a number of questions pertaining to the blueprint or blueprints you use for the lesson. Many questions will involve mathematics, electrical knowledge, and electrical installation work. Use the electrical symbols sheet to learn the various symbols found on the print. Discuss a pictorial drawing and its use. Make a bill of material for a small installation.

APPLICATION:

Practice work on blueprints until the students have a good understanding of the work.

CHECKING AND FOLLOW-UP:

Check and discuss answers the students listed on the answer sheets for the blueprints studied.

BLUEPRINT READING

GENERAL OUTLINE

1. Plans are:

   (a) Pictures of the project - by construction trade
   (b) Details of the construction methods to be used
   (c) Pictorial diagram of how it works
   (d) Bill of materials (equipment lists, fixture schedules)
   (e) Wiring diagrams and schematic diagrams
   (f) The "how" and "where" of the contract

2. Specifications are:

   (a) The "who," "what," "when" of the contract
   (b) Construction guidelines - standards of performance
   (c) Special clauses and verbal pictures of requirements

3. The building trades:

   (a) Civil
   (b) General
   (c) Plumbing
   (d) Heating, ventilating, and air conditioning
   (e) Electrical

4. Symbol schedules:

   (a) Architectural
   (b) Civil
   (c) Structural
   (d) Mechanical
   (e) Electrical

5. Scales used:

   (a) Architects
   (b) Engineers
   (c) Metric
   (d) Graphic
   (e) Half-size

Electrical Symbols Commonly Used on Blueprints

GENERAL OUTLETS

Ceiling	Wall	
○	-○	Outlet.
Ⓑ	-Ⓑ	Blanked Outlet.
Ⓓ		Drop Cord.
Ⓔ	-Ⓔ	Electrical Outlet; for use only when circle used alone might be confused with columns, plumbing symbols, etc.
Ⓕ	-Ⓕ	Fan Outlet.
Ⓙ	-Ⓙ	Junction Box.
Ⓛ	-Ⓛ	Lamp Holder.
$Ⓛ_{PS}$	$-Ⓛ_{PS}$	Lamp Holder with Pull Switch.
Ⓢ	-Ⓢ	Pull Switch.
Ⓥ	-Ⓥ	Outlet for Vapor Discharge Lamp.
⊗	-⊗	Exit Light Outlet.
Ⓒ	-Ⓒ	Clock Outlet. (Specify Voltage.)

CONVENIENCE OUTLETS

=⊖	Duplex Convenience Outlet.
$=\ominus_{1,3}$	Convenience Outlet other than Duplex. 1=Single, 3=Triplex, etc.
$=\ominus_{WP}$	Weatherproof Convenience Outlet.
$\equiv\ominus_{R}$	Range Outlet.
$=\ominus_{S}$	Switch and Convenience Outlet.
=⊖Ⓡ	Radio and Convenience Outlet.
●	Special Purpose Outlet. (Des. in Spec.)
⊙	Floor Outlet.

SWITCH OUTLETS

S	Single Pole Switch.
S_2	Double Pole Switch.
S_3	Three-Way Switch.
S_4	Four-Way Switch.
S_D	Automatic Door Switch.
S_E	Electrolier Switch.
S_K	Key Operated Switch.
S_P	Switch and Pilot Lamp.
S_{CB}	Circuit Breaker.
S_{WCB}	Weatherproof Circuit Breaker.
S_{MC}	Momentary Contact Switch.
S_{RC}	Remote Control Switch.
S_{WP}	Weatherproof Switch.
S_F	Fused Switch.
S_{WF}	Weatherproof Fused Switch.

SPECIAL OUTLETS

$○_{a,b,c,etc}$
$=\ominus_{a,b,c,etc}$
$S_{a,b,c,etc}$

Any Standard Symbol as given above with the addition of a lower case subscript letter may be used to designate some special variation of Standard Equipment of particular interest in a specific set of Architectural Plans. When used, they must be listed in the Key of Symbols on each drawing and if necessary further described in the specifications.

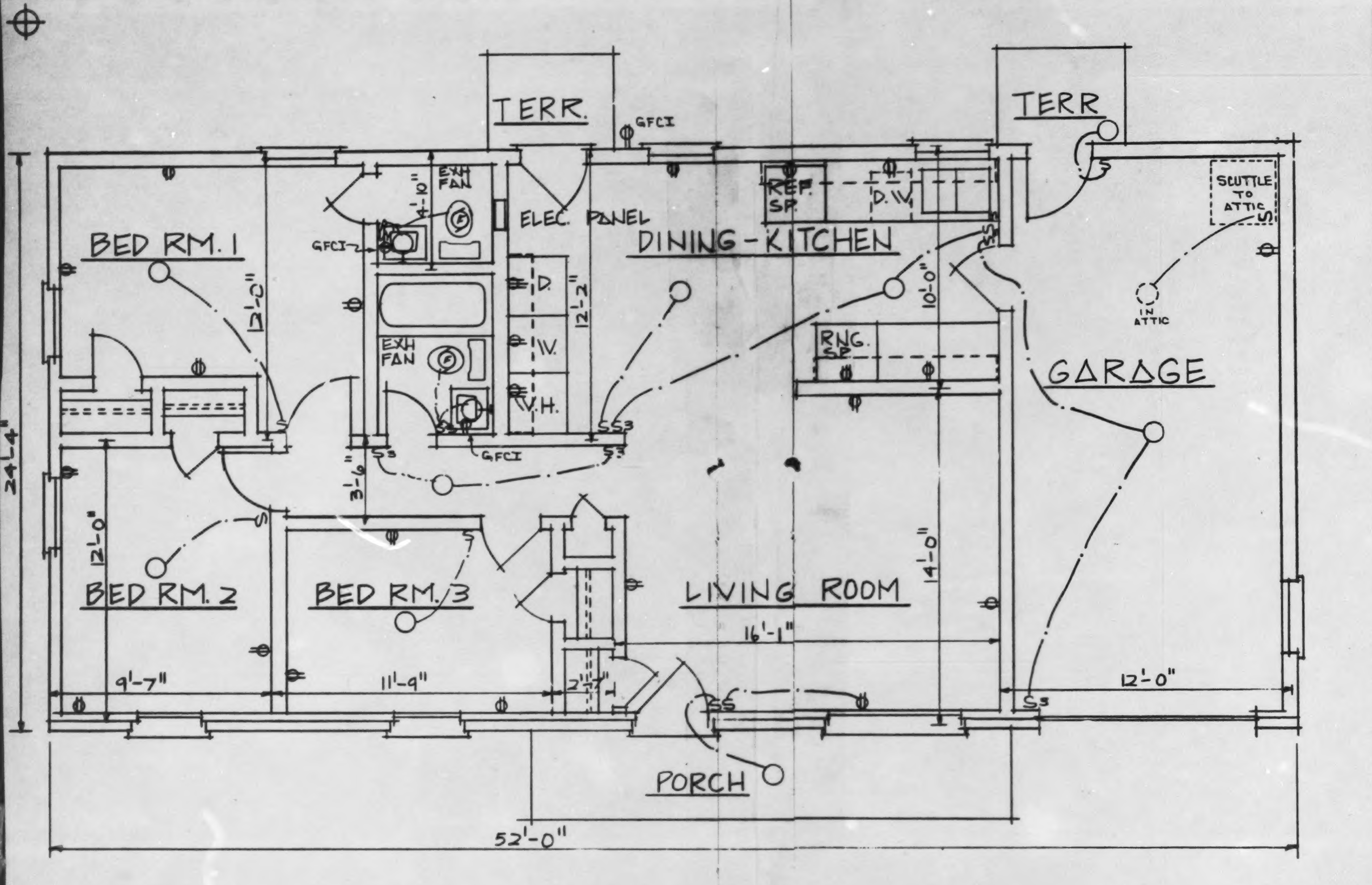
Courtesy of American Standards Association of New York, N.Y.

PANELS, CIRCUITS, AND MISCELLANEOUS

■	Lighting Panel.
▨	Power Panel.
——	Branch Circuit; Concealed in Ceiling or Wall.
-·-·-	Branch Circuit; Concealed in Floor.
-----	Branch Circuit; Exposed.
—→	Home Run to Panel Board. Indicate number of Circuits by number of arrows. Note: Any circuit without further designation indicates a two-wire circuit. For a greater number of wires indicate as follows -///- (3 wires) -////- (4 wires), etc.
▬	Feeders. Note: Use heavy lines and designate by number corresponding to listing in Feeder Schedule.
≡□≡	Underfloor Duct and Junction Box. Triple System. For double or single systems, eliminate 1 or 2 lines. This symbol equally adaptable to auxiliary system layouts.
Ⓖ	Generator.
Ⓜ	Motor.
Ⓘ	Instrument.
Ⓣ	Power Transformer. (Or draw to scale.)
⊠	Controller.
□	Isolating Switch.

AUXILIARY SYSTEMS

⊡	Push Button.
□	Buzzer.
□	Bell.
-◇	Annunciator.
◀	Outside Telephone.
◁	Interconnecting Telephone.
◁	Telephone Switchboard.
Ⓣ	Bell Ringing Transformer.
D	Electric Door Opener.
F	Fire Alarm Bell.
F	Fire Alarm Station.
⊠	City Fire Alarm Station.
FA	Fire Alarm Central Station.
FS	Automatic Fire Alarm Device.
W	Watchman's Station.
W	Watchman's Central Station.
H	Horn.
N	Nurse's Signal Plug.
M	Maid's Signal Plug.
R	Radio Outlet.
SC	Signal Central Station.
□	Interconnection Box.
‖	Battery.
-·-·-	Auxiliary System Circuits. Note: Any line without further designation indicates a 2-Wire System. For a greater number of wires designate with numerals in manner similar to —·—12-No. 18W-¾" C., or designate by number corresponding to listing in Schedule.
$□_{a,b,c}$	Special Auxiliary Outlets. Subscript letters refer to notes on plans or detailed description in specs.


TERR.
GFCI
TERR
EXH FAN
4'-10"
ELEC. PANEL
BED RM. 1
GFCI
13'-0"
DINING-KITCHEN
REF. SP.
D.W.
SCUTTLE TO ATTIC
S
IN ATTIC
D.
W.
V.H.
12'-2"
10'-0"
RNG. SP.
GARAGE
EXH FAN
GFCI
S3
3'-6"
24'-4"
12'-0"
BED RM. 2
BED RM. 3
LIVING ROOM
14'-0"
16'-1"
9'-7"
11'-9"
2'-7"
12'-0"
PORCH
52'-0"

FLOOR PLAN

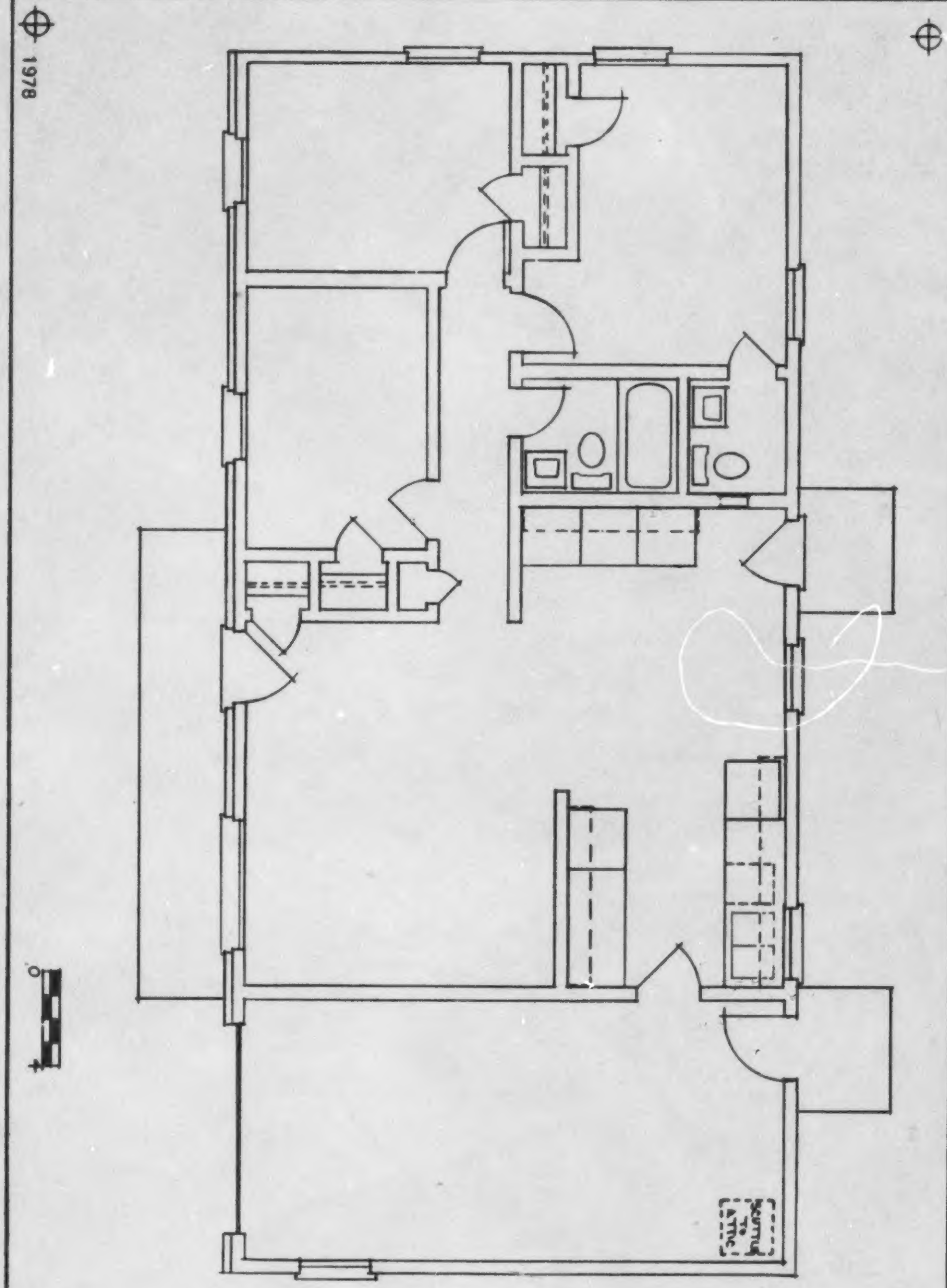
1978

STUDENT: GARY ROBBINS
STUDENT NO. 6248
326 PINEVIEW ST
ASHEBORO, N.C.
SHEET NO. 1 OF 1.

FLOOR PLAN

GUILFORD TECHNICAL
INSTITUTE, JAMESTOWN N.C.

ARCHITECTURAL
TECHNOLOGY DEPARTMENT


1978
SCUTTLE TO ATTIC

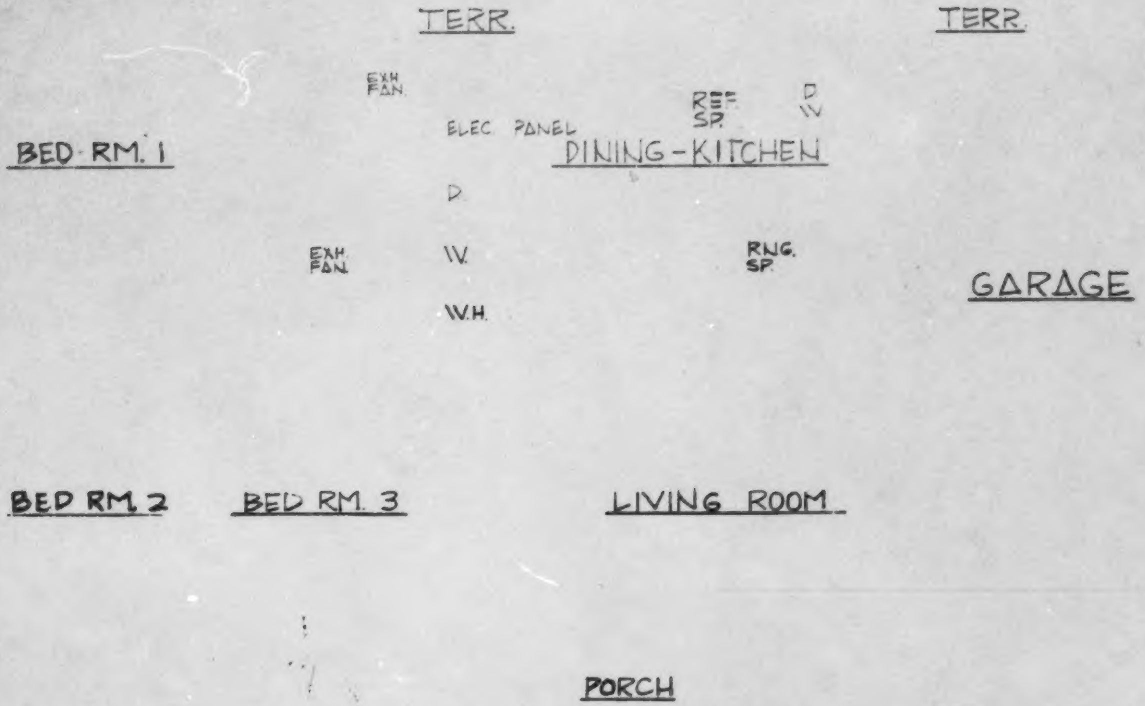
GUILFORD TECHNICAL
INSTITUTE, JAMESTOWN, N.C.

ARCHITECTURAL
TECHNOLOGY DEPARTMENT

FLOOR PLAN

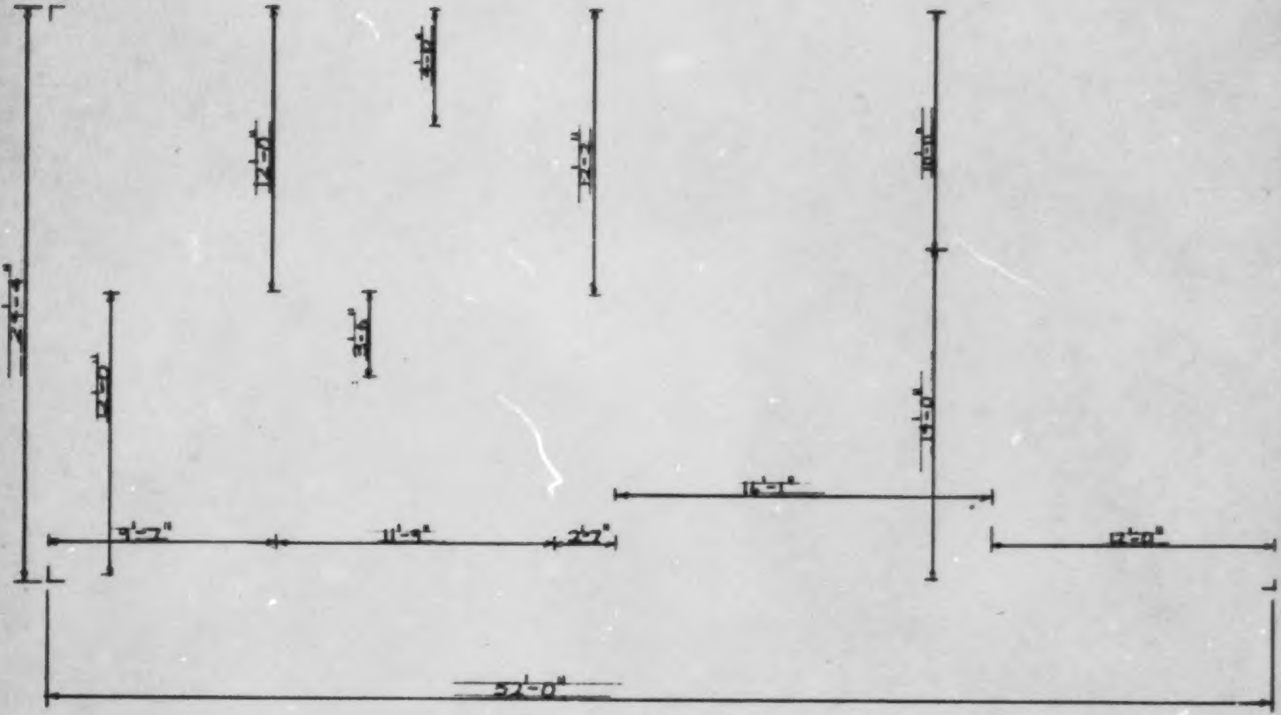
STUDENT: GARY ROBBINS
STUDENT NO. 6248
326 PINEVIEW ST.
ASHEBORO, N.C.

SHEET NO. 1 OF 1

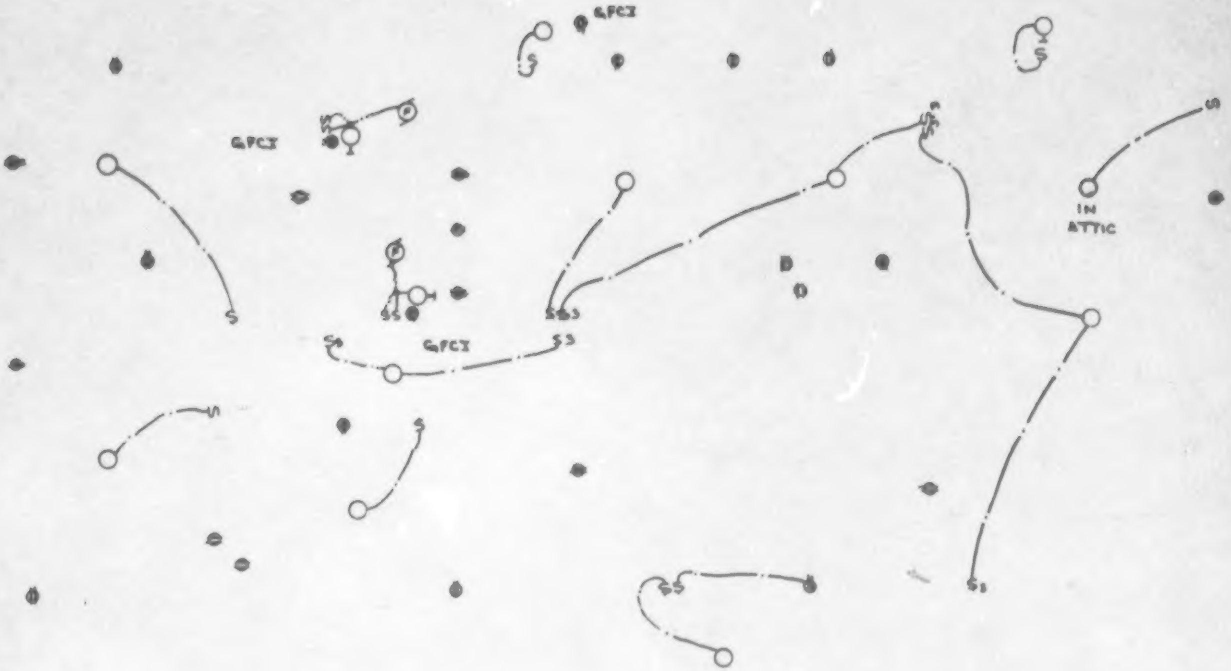

TERR.
TERR.
EXH. FAN.
REF. SP.
D. W.
ELEC. PANEL
BED RM. 1
DINING-KITCHEN
D.
EXH. FAN.
W.
RNG. SP.
GARAGE
W.H.
BED RM. 2
BED RM. 3
LIVING ROOM
PORCH

1978

162


9'-7"
11'-9"
2'-7"
16'-1"
12'-0"
52'-0"
17'-0"

1978


GFCI
S
GFCI
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GFCI
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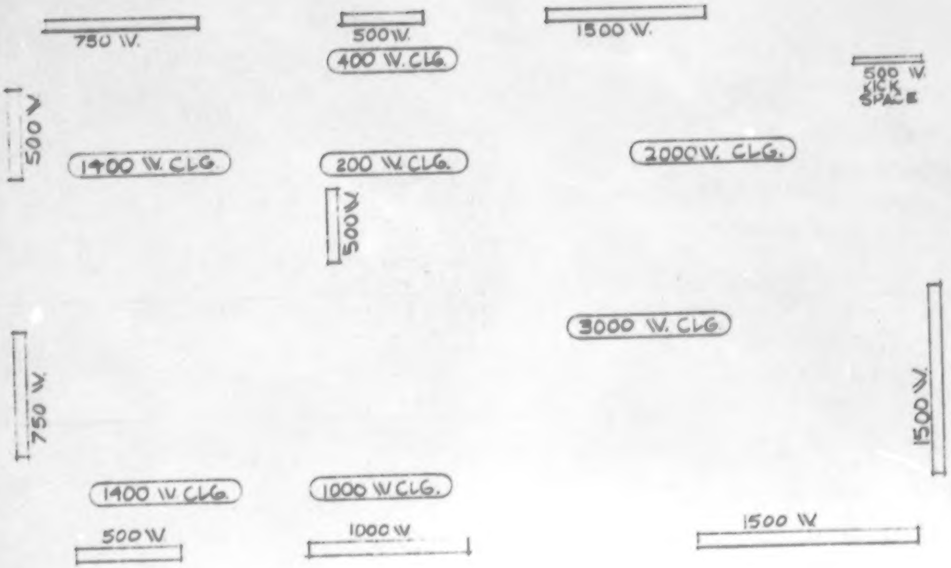
1978


750 W.
500 W.
400 W. CLG.
1500 W.
500 W. KICK SPACE
500 W
1400 W. CLG.
200 W. CLG.
2000 W. CLG.
500 W.
3000 W. CLG.
750 W.
1500 W.
1400 W CLG.
1000 W CLG.
500 W
1000 W
1500 W

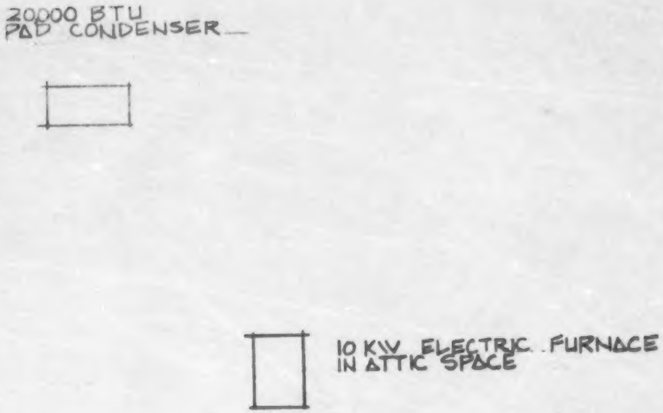
6500 KW BASE BOARD HEAT
OR
(9400 KW CEILING CABLE HEAT)

1978

8000 BTU
AIR CONDITIONER
15000 BTU
AIR CONDITIONER

WINDOW AIR CONDITIONERS
2300 BTU

1978


20000 BTU
PAD CONDENSER
10 KW ELECTRIC FURNACE
IN ATTIC SPACE

10 KW ELECTRIC FURNACE
WITH AIR CONDITIONER

1978

UNIT TESTS

(SERIES A)

Note to Instructors: The enclosed exams are provided for your use and guidance. You may wish to make up your own tests, based on your particular class presentations.

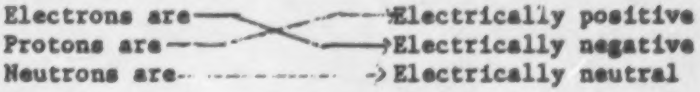
NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-1
LESSON A-7 THRU A-12

1. The atom is electrically neutral because it consists of equal numbers of positive and negative charges. True/False TRUE

2. Draw an arrow to connect the correct answers:



Electrons are Electrically positive
Protons are Electrically negative
Neutrons are Electrically neutral

3. It is the motion of free electrons which makes up an electric circuit. True/False TRUE

4. The atom is the smallest physical particle into which an element can be divided. True/False TRUE

5. The molecule is a combination of two or more atoms. True/False TRUE

6. True or False

a. Copper is the best conductor. TRUE
b. Voltage is measured in unit of volts. TRUE
c. The flow of electricity is due to the movement of electrons. TRUE
d. An ammeter is connected parallel in a circuit. FALSE
e. A direct current always flows in the same direction. TRUE
f. A voltmeter is used to measure the resistance in a circuit. FALSE

7. a. An electric current is measured in AMPERES.
b. Give symbol for current. I

8. List four factors affecting resistance of a conductor.

a. MATERIALS OF CONDUCTOR
b. DIMENSION OF CONDUCTOR
c. TEMPERATURE
d. DISTRIBUTION OF CURRENT OVER CROSS-SECTIONAL AREA OF CONDUCTOR

9. Choose one.

a. Conductors of A. LOW resistivity are used for transmission line and feeders. (A. Low B. High)
b. Conductors of B. HIGH resistivity are used for incandescent lamps and toasters. (A. Low B. High)

NAME ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-1
LESSON A-7 THRU A-12

10. The two wire gages used in this country are:

a. AMERICAN WIRE GAGE (AWG)
b. BROWN & SHARPE (B & S)

11. Match Column B with Column A.

	A	B
5	A. The symbol for voltage.	1. Ohms
4	B. The instrument used to measure voltage.	2. Electrical pressure
		3. Resistance
2	C. EMF	4. Voltmeter
1	D. Resistance measured in.	5. E
3	E. Opposes current flow.	6. Voltage ÷ Resistance
6	F. Current	7. Resistance ÷ Voltage

12. A loose connection on conductors will ([✓ increase], decrease) the resistance?

13. Resistance ([✓ increases], decreases) with an increase in temperature.

14. Express Ohm's law for finding voltage. $E = I \times R$

15. Express Ohm's law for finding current. $I = \frac{E}{R}$

16. Express Ohm's law for finding resistance. $R = \frac{E}{I}$

17. If ten lamps of 100 watts each were burned for one hour, how much power would be used? ONE KILOWATT HOUR

18. One horsepower equals 746 (750) watts.

19. How could an electric motor have an efficiency of 100%? Explain.
HAVE NO WATTS LOST THRU THE MOTOR WINDINGS AND BEARINGS WHICH WOULD BE FRICTIONLESS.

0. A motor draws 3 amperes and operates at 250 volts. How much power is consumed? 750 WATTS What is the horsepower rating of this motor? 1 HP

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-2
LESSON A-13 THRU A-15

1. True or False

   a. In a series circuit, current remains the same throughout the circuit. TRUE
   b. In a series set of Christmas tree lights, if one lamp burns out, the other lamps will continue to burn. FALSE
   c. In a series circuit there is more than one path for current to flow. FALSE
   d. The total resistance is always smaller than the smallest resistor connected parallel in a parallel circuit. TRUE

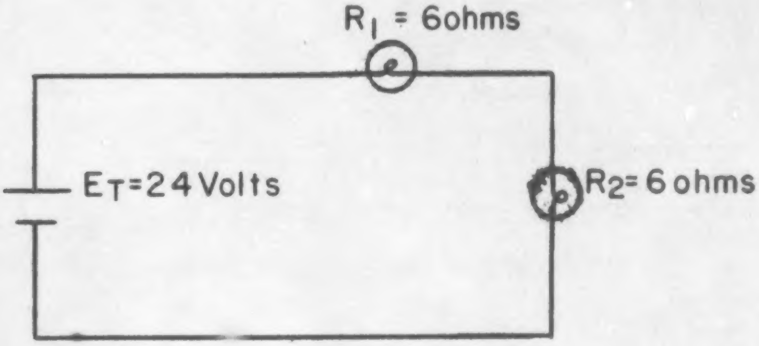
2. List two disadvantages of series circuits:

   a. A BREAK IN A PORTION OF THE CIRCUIT STOPS THE WHOLE CIRCUIT
   b. VOLTAGE IS UNSTABLE THROUGHOUT CIRCUIT

3. List two advantages of parallel circuits.

   a. VOLTAGE ACROSS ANY BRANCH IS EQUAL TO EACH OTHER AND TO TOTAL VOLTAGE, I.E., CONSTANT VOLTAGE
   b. DEVICES OPERATE INDEPENDENTLY OF ONE ANOTHER

4. Solve for current: ANSWER: $I_T = 2$ AMPERES



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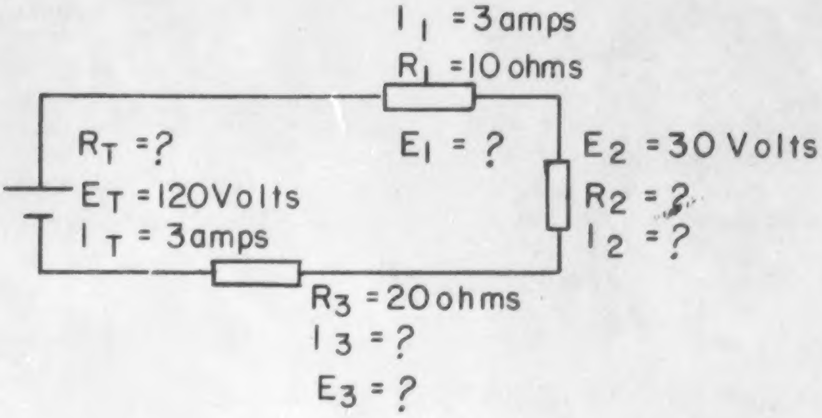
TEST A-2
LESSON A-13 THRU A-15

5. Solve for each unknown:



I1 =3amps
R1 =10ohms
RT =?
E1 = ?
E2 =30Volts
ET =120Volts
R2 = ?
IT = 3amps
I2 =?
R3 =20ohms
I3 =?
E3 =?

R_T = 40 OHMS

E_1 = 30 VOLTS

I_2 = 3 AMPS

R_2 = 10 OHMS

E_3 = 60 VOLTS

I_3 = 3 AMPS

6. Describe the following symbols:

a. E_T TOTAL VOLTAGE

b. I_1 CURRENT IN FIRST PART OF CIRCUIT

c. R_4 RESISTANCE IN FOURTH PART OF CIRCUIT

d. I_T TOTAL CURRENT

e. E_1 VOLTAGE IN FIRST PART OF CIRCUIT

f. E_4 VOLTAGE IN FOURTH PART OF CIRCUIT

g. R_T TOTAL RESISTANCE

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7. Write the two formulas for finding total resistance in parallel.

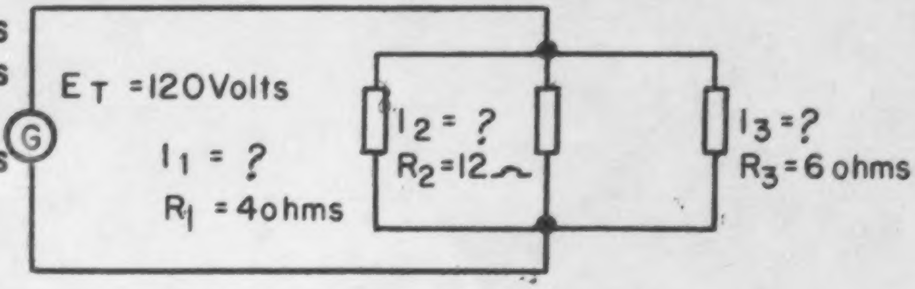
a. $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$

b. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_N}$

8. Find the total current and current in each branch of the following circuit:

ANSWER

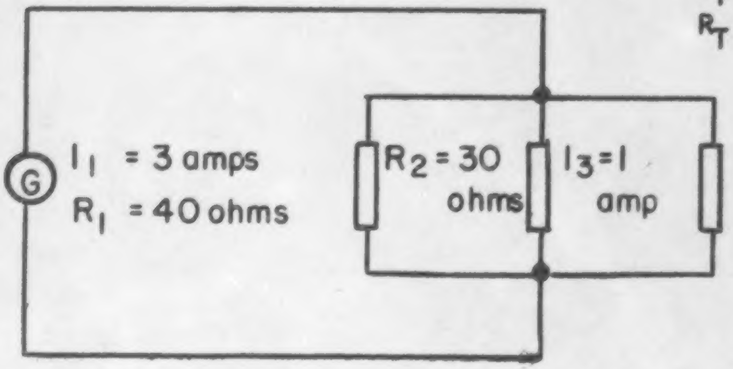
I_1 = 30 AMPS
I_2 = 10 AMPS
I_3 = 20 AMPS
I_T = 60 AMPS



G
E T = 120 Volts
I1 = ?
R1 = 4 ohms
I2 = ?
R2 = 12 Ω
I3 = ?
R3 = 6 ohms

9. Find the total voltage, total current and total resistance of the following circuit:

ANSWER: E_T = 120 VOLTS
I_T = 8 AMPS
R_T = 15 OHMS



G
I1 = 3 amps
R1 = 40 ohms
R2 = 30 ohms
I3 = 1 amp

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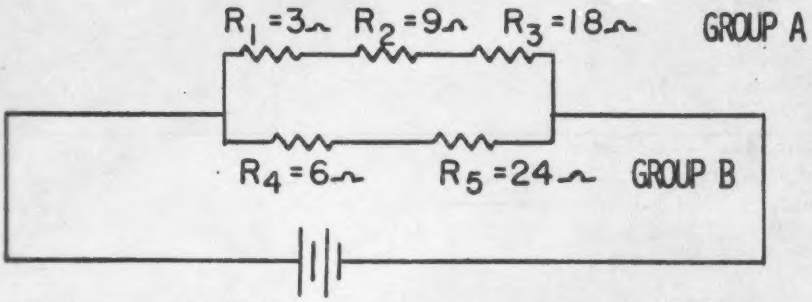
LESSON A-13 THRU A-15

10. Find the total resistance of the following circuit.


$R_1 = 3\Omega$
$R_2 = 9\Omega$
$R_3 = 18\Omega$
GROUP A
$R_4 = 6\Omega$
$R_5 = 24\Omega$
GROUP B

GROUP A (SERIES)

$R_{T(A)} = 3 + 9 + 18$

$R_{T(A)} = 30$

GROUP B (SERIES)

$R_{T(B)} = 6 + 24$

$R_{T(B)} = 30$

ANSWER

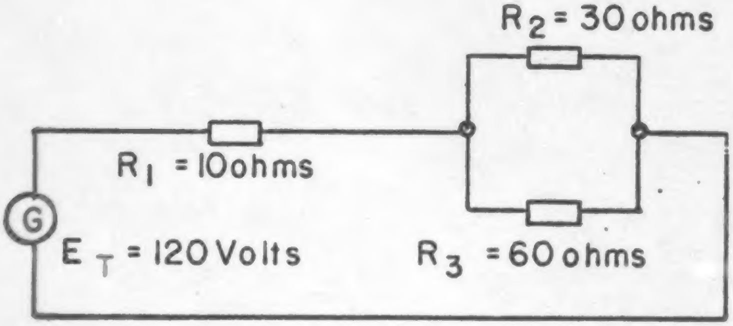
TOTAL CIRCUIT RESISTANCE
NOW IS PARALLEL CIRCUIT

$$\frac{1}{R_{T\,(A)}} + \frac{1}{R_{T(B)}} =$$

$$\frac{1}{30} + \frac{1}{30} = \frac{1}{R_T}$$

$$15 = R_T$$

11. Solve for all values of current, resistance and voltage.


R_2 = 30 ohms
R_1 = 10ohms
G
E_T = 120 Volts
R_3 = 60 ohms

ANSWER:

E_1 = 40 volts
E_2 = 80 volts
E_3 = 80 volts
I_2 = 2.66 amps (approx.)
I_3 = 1.33 amps (approx.)
I_T = 4 amps
R_T = 30 ohms

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TEST A-3
LESSON A-16 THRU A-18

1. Copper is the most commonly used material for wires and cables due to its LOW resistance.

2. If aluminum wires are used, a LARGER size wire may have to be used to carry the current necessary to serve the load.

3. A conductor is a wire or combination of wires, not INSULATED from each other, and suitable for carrying a SINGLE electric current.

4. A cable is a SINGLE conductor or a GROUP of two or more conductors laid together but INSULATED from one another.

5. A good conductor has high/low resistance. LOW

6. Increasing the wire size raises/lowers the resistance if the same load is applied. LOWERS

7. Check the five factors used to determine the type of insulation a conductor must have.

   a. X Wet Locations
   b. X Dry Locations
   c. X Temperature
   d. _____ Length
   e. X Special Applications
   f. X Specific Locations
   g. _____ Altitude
   h. _____ Load to be carried

8. The longer the conductor, the greater/less the resistance. GREATER

9. Match the definition with the correct word it describes:

   a. Insulated
   b. Bare
   c. Covered
   d. Jacketed

   C Has a covering to protect from mechanical injury only
   D Has a covering to protect from hard service locations and exposure to moisture
   B Has no covering
   A Has a covering of material recognized as insulat[illegible]

NAME ____________________________

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TEST A-3
LESSON A-16 THRU A-18

10. Can a cable provide the following and still be encased in one jacket? [✓ Yes]/No

    1. Carry 6 volt sound pair conductors.
    2. Carry 120 volt lighting circuit.
    3. Carry 480 volt power circuit.
    4. Carry a 240 volt DC power circuit.

11. If the answer to question #10 above is "yes", give the conditions which have to be met. If the answer is "no", give the reason it cannot be done. ALL MAY BE INSTALLED IN A CABLE ASSEMBLY IF EACH CONDUCTOR IS INSULATED FOR THE MAXIMUM VOLTAGE OF ANY CONDUCTOR WITHIN THE CABLE. (NEC 300-3 (2)

12. The voltage drop of a 3 phase 4 wire circuit which is nearly balanced is about the same as a two wire single phase circuit. [✓ True]/False TRUE

13. Why can the same ampere load be carried twice as far on a 277 volt circuit as on a 120 volt circuit? BECAUSE THE VOLTAGE IS OVER TWICE AS HIGH WHICH MAKES THE VOLTAGE DROP ONLY HALF AS LARGE.

14. Under most circumstances the resistance of an AC circuit is equal to a DC circuit when calculating voltage drop. [✓ True]/False

15. Voltage drop in a circuit can be eliminated. True/[✓ False] FALSE

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ELECTRICAL APPRENTICE
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TEST A-4
LESSON A-19 THRU A-20

1. The NEC contains MINIMUM provisions considered necessary for safety.

2. A general purpose branch circuit supplies outlets for LIGHTING and APPLIANCES.

3. In general, COPPER conductors are used to conduct current.

4. The minimum size conductor permitted for general interior wiring shall be No. 14 AWG.

5. A maximum of 6 fusible switches or circuit breakers may be used as service equipment.

6. A motor circuit switch is HP rated and capable of OPERATING under load.

7. The GROUNDED conductor is intentionally grounded.

8. WOODEN plugs are not approved for securing equipment to masonry walls.

9. SOLID conductors, No.10 AWG and smaller, may be installed in a conduit.

10. Only Type USE cable shall be installed for underground service entrance conductors.

11. A safety switch is an example of a DISCONNECTING means.

12. Field applied insulation over the conductor splices shall be EQUAL in value to the conductor insulation.

13. All UNGROUNDED conductors shall be protected by an overcurrent device.

14. All holes in outlet boxes shall be PLUGGED.

15. The NEC is not intended as a DESIGN specification.

16. A FEEDER is a circuit conductor between the switchboard and the branch circuit protective device.

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ELECTRICAL APPRENTICE
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FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

17. A minimum of 6 inches of free conductor shall be provided at each outlet or switch.

18. The minimum mounting height of an overhead service drop is 10 feet above grade.

19. A multi-wire BRANCH CIRCUIT consists of two or more undergrounded conductors having a potential difference between them and an identified grounded conductor having an equal potential difference between it and each of the ungrounded conductors.

20. The NEC mandatory rules are characterized by the word "SHALL".

21. Electrical equipment mounted a minimum of 8 feet above the floor is a substitute for the required floor mounted horizontal clearance.

22. Equipment grounding conductors shall not be FUSED.

23. Lath shall not be used to support OUTLET boxes.

24. The minimum size service entrance conductor is No. 8 AWG.
(COPPER) NOT MORE THAN TWO - 2 WIRE BRANCH CIRCUITS.

25. ISOLATING switches have no interrupting rating and shall be operated only after the circuit is dead.

26. SERVICE ENTRANCE conductors are located between the service drop and service equipment.

27. All conduits shall be CONTINUOUS from outlet to outlet.

28. The maximum number of No. 10 AWG conductors permitted in a 1 1/2 inch x 4-inch square outlet box shall be 8.

29. The minimum size grounding conductor for three parallel 300 MCM service conductors shall be NO. 2/0 AWG.

30. Neutral conductors shall not be FUSED.

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ELECTRICAL APPRENTICE
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FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

31. Outlet boxes in wood walls shall be set FLUSH with finished surface.

32. Conductor SPLICES or TAPS shall not be made within raceway.

33. A general purpose switch is rated in AMPERES and capable of OPERATING at its rated current and voltage.

34. DRY locations are not normally subject to dampness or wetness.

35. The minimum size conductor permitted for multiple or parallel runs shall be No. 1/0 AWG.

36. A vertical run of 350 MCM copper feeder shall be supported on a maximum 60 - foot center.

37. ROUND outlet boxes shall not be installed on a conduit system requiring locknuts and bushings.

38. A right angle pull junction box with entering and exiting conduits sized: 3-inch and 4-inch shall be a minimum of 27" LONG x 27" WIDE inches. TRADE SIZE 30 X 30

39. A metallic UNDERGROUND WATER piping system is the best grounding electrode.

40. Overhead service conductors shall form a DRIP loop at the service head.

41. Metal STRAPS shall not be used to make grounding connection to water system.

42. Insulated bushings shall be installed on raceways for No. 4 AWG and larger conductors.

43. Conductors of different systems may be installed in the same conduit provided all conductors are INSULATED for the MAXIMUM VOLTAGE on any of the conductors.

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TEST A-4
LESSON A-19 THRU A-20

44. A lighting fixture exceeding ___6___ pounds shall not be supported from the lampholder screw-shell.

45. A straight pull junction box with a 3-inch conduit entering and exiting shall have a minimum length of ___24___ - inches.

46. The minimum size grounding conductor for service conductors shall be No. ___8___ AWG.

47. A lighting fixture exceeding ___50___ pounds shall be supported from the building structural members.

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TEST A-5
LESSON A-21 THRU A-24

1. Single conductor wiring is restricted to residential wiring only. True/[✓ False]

2. The conductor separation for open wiring for voltage not exceeding 300 volts is 2 1/2 inches, and for voltage not exceeding 600 volts is 4 inches.

3. Conductor separation for concealed knob and tube work is the same as open wiring. True/[✓ False]

4. Bare conductor feeders can be installed on bar joists or beams if a minimum clearance of 8 feet is allowed. True/[✓ False]

5. Open and concealed knob and tube wiring and bare conductor feeders have the same ampacity rating as conductors installed in conduit. True/[✓ False]

6. The code designations on non-metallic sheathed cable are:

   a. NM
   b. NMC

7. The basic difference in the two cables listed above is NMC HAS FUNGUS AND CORROSION RESISTANT COVERING OVER ALL.

8. Conductor sizes for non-metallic sheathed cable range from # 14 thru # 2 for copper conductors and # 12 thru # 2 for aluminum conductors.

9. The uninsulated or bare conductor is for GROUNDING purposes only.

10. The insulation of the individual conductors shall comply with the requirements for the type of conductors used. [✓ True]/False

11. The code designations of service-entrance cable are (a) S E (b) U S E .

12. Can the uninsulated conductor of service entrance cable used as a branch circuit be used as the neutral. [✓ Yes]/No EXAP. #1 § 250-60

13. Underground feeder and branch circuit cable has the code designation of type U F .

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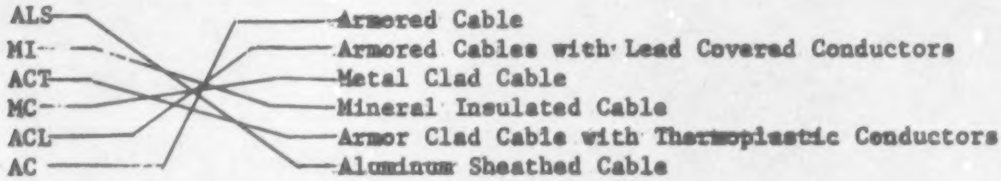
TEST A-5
LESSON A-21 THRU A-24

14. What is the minimum depth for cables buried directly in the earth? 18 . Can this depth be reduced? [✓ Yes]/ No

15. Listed below are the Code type designations and descriptions. Draw a line to connect the correct type with its description.



ALS	Armored Cable
MI	Armored Cables with Lead Covered Conductors
ACT	Metal Clad Cable
MC	Mineral Insulated Cable
ACL	Armor Clad Cable with Thermoplastic Conductors
AC	Aluminum Sheathed Cable

16. The mineral insulation used in type MI cable is MAGNESIUM OXIDE .

17. The individual conductors of multi-conductor type M. I. cable have no individual insulation. [✓ True]/False

18. What are the four major insulating materials used for conductor insulation?

a. RUBBER-NATURAL
b. SYNTHETIC RUBBER
c. THERMOPLASTICS
d. OTHER VULCANIZABLE MATERIAL

19. The support methods for metallic sheathed cables are the same as other cable assemblies. True/[✓ False]

20. When flexible cord is used to serve an appliance or lamp the cord will be equipped with an attachment plug. [✓ True]/False

21. Splices can be made in flexible cord. [✓ True]/False

22. Tying a knot in the conductors of a flexible cord to keep strain off the terminal screws is prohibited by the Code. True/[✓ False]

23. A flexible cord containing more than three (3) current-carrying conductors has to be de-rated. [✓ True]/False

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ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-5
LESSON A-21 THRU A-24

24. In a five conductor flexible cord there are five different color conductors as listed below. Give the proper name for the intended use of each colored conductor:

a. Black UNGROUNDED CONDUCTOR
b. Red UNGROUNDED CONDUCTOR
c. Blue UNGROUNDED CONDUCTOR
d. White IDENTIFIED CONDUCTOR (NEUTRAL)
e. Green EQUIPMENT GROUNDING CONDUCTOR (GROUND)

25. All flexible cords have a grounding conductor. True/[✓ False]

26. Fixture wires can be used as branch circuit conductors. True/[✓ False]

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ELECTRICAL APPRENTICE
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TEST A-6
LESSON A-25 THRU A-30

1. Rigid metal conduit shall be installed in a minimum of 1 1/2 feet below cinder fill.

2. E.M.T. shall not be installed on systems exceeding 600 volts.

3. The standard length of rigid metal conduit or EMT is 10 feet.

4. On exposed E.M.T. installations in wet locations, RAIN-TIGHT threadless couplings and connectors shall be used.

5. The number of bends and offsets in one run of conduit shall not exceed 360 degrees.

6. E.M.T. shall not be installed in a CINDER fill.

7. Flexible metal conduit shall be supported on maximum 4 1/2 foot centers.

8. E.M.T. installed in concrete shall be provided with CONCRETE-TIGHT threadless couplings and connectors.

9. The maximum size conductor permitted in a 2-inch liquid-tight flexible conduit shall be No. 2/0 AWG.

10. All fittings for E.M.T. shall be the THREADLESS type.

11. Outlet boxes used for interior wiring are classified into the following groups:

    a. OUTLET BOX
    b. UTILITY BOX
    c. SECTIONAL SWITCH BOX
    d. FLOOR BOX

12. List the most important items which determine which type outlet or switch box must be used:

    a. NUMBER OF CONDUCTORS
    b. SIZE OF CONDUCTORS
    c. DEVICES OR FIXTURES ATTACHED
    d. LOCATION INSTALLED

13. What determines the length of a straight thru junction box? Circle the right answer. B

    a. Number of wires.
    [✓ b. Size of conduit.]
    c. Number of conduits.
    d. Number of joints to be made in the box.

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TEST A-6
LESSON A-25 THRU A-30

14. What determines the length of an angle or u-pull junction box? Circle the right answers.

    a. Number of wires.
    b. [✓ Size of conduit].
    c. [✓ Number of conduits].
    d. Number of joints to be made in the box.

15. Boxes over 100 cubic inches in size are classified as a CABINET or CUT OUT box.

16. What is the main difference between an auxiliary gutter and a wireway? AUXILIARY GUTTER IS LIMITED TO 30 FT. IN LENGTH.

17. Can splices and taps be made in auxiliary gutters and wireways? [✓ Yes]/No. If the answer is 'yes' under what conditions may they be made. PROVIDING NOT OVER 20% OF CROSS-SECTIONAL AREA IS EXCEEDED

18. The Code limits the number of current carrying conductors to 30 in both auxiliary gutters and wireways. True/[✓ False.]

19. Does Note #8 to Tables 310-16 through 310-19 apply to auxiliary gutters and wireways? [✓ Yes]/No

20. Does a 20% fill capacity limit apply to auxiliary gutters and wireways? [✓ Yes]/No

21. If the answer to the above question is 'yes' or 'no' circle the one to which the 20% fill is applicable.

    a. Auxiliary Gutter   b. Wireway   [✓ c. Both]

22. Can un-used knock-outs be left open in the bottom of a cabinet or cut-out box for ventilation? Yes/[✓ No]. Give the Code section and paragraph rule for your answer. 373-4

23. A single 500 MCM conductor per phase is loop fed thru one panel with double barrell lugs to another panel. What is the minimum width. gutter allowed? 8 INCHES

24. Name six (6) methods by which extensions can be made from a wireway to other items of electrical equipment.

    a. RIGID METAL CONDUIT
    b. FLEXIBLE METAL CONDUIT
    c. SURFACE METAL RACEWAY
    d. METAL CLAD CABLE
    e. E.M.T.
    f. INTERMEDIATE METAL CONDUIT

NAME ______________________

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ELECTRICAL APPRENTICE
TECHNICAL TRAINING
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TEST A-7
LESSON A-31 THRU A-36

1. Match the correct word or number with the statement which best describes it:

   a. Visual Comfort
   b. Brightness
   c. Glare
   d. 186,000 Miles Second
   e. Foot Candles
   f. Light Bulb

   D 1. The speed of light.
   C 2. Light "out of place" causing eye discomfort or interference with vision
   E 3. The unit of illumination or light density equal to one lume per square foot.
   B 4. An expression related to the degree of brilliancy of any surface omitting or reflecting light.
   A 5. Freedom from direct or reflected glare.
   F 6. A device for converting electrical energy into visible radiant energy.

2. Rate the three basic light sources as to their efficiency in lumen per watt output: (1st, 2nd, 3rd)

   1 [✓ 2] 3 Flourescent

   1 2 [✓ 3] Incandescent

   [✓ 1] 2 3 High Intensity Discharge

3. High intensity discharge lamps can be separated into the following major categories:

   a. MERCURY
   b. METAL HALIDE
   c. HIGH PRESSURE SODIUM

4. All lamps have similar component parts. List below the five (5) most common parts of a lamp.

   a. BASE
   b. FILAMENT
   c. BULB
   d. FILLING GAS
   e. BULB COATING

NAME ______________________

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TEST A-7
LESSON A-31 THRU A-36

5. What is a Class 'P' ballast? A BALLAST WHICH CONTAINS INHERENT THERMAL PROTECTION WHICH WILL AUTOMATICALLY OPEN IF THE MAXIMUM TEMPERATURE OF THE BALLAST IS EXCEEDED. (105°C WITHIN WINDINGS)

6. The five principal methods of flourescent lamp operation are:

a. PREHEAT
b. TRIGGER START
c. RAPID START
d. INSTANT START
e. SLIMLINE

7. What are the four classifications of high-intensity discharge lamps?

a. MERCURY
b. METAL HALIDE
c. HIGH PRESSURE SODIUM
d. SPECIAL TYPES

8. What is the basic difference in the three major types of high-intensity-discharge lamps?

a. Shape
b. Lumen output
[✓ c. Vaporizing metal used]
d. Mounting position

9. What percent overload is a fuse capable of carrying before blowing?

a. 10%
b. 25%
c. 45%
[✓ d. 125%]

10. Match the following letter to correspond with the matching number?

B 1. Plug fuse
C 2. Cartridge fuse at 250 volts
A 3. Silver sand

a. maximum rating 6000 ampere
b. maximum rating 30 ampere
c. maximum rating 600 ampere

11. Dual element cartridge fuses contain a thermal element and a fuse link. [✓ True]/False

12. Temperature will affect the operation of thermally controlled circuit breakers and must be considered in the application and sizing. [✓ True]/False

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ELECTRICAL APPRENTICE
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TEST A-7
LESSON A-31 THRU A-36

13. Lead-acid type batteries are rated 2 volts per cell.

14. Fuses are rated in VOLTS and AMPERES, and have a LOW resistance.

15. Alkali-type batteries are rated 1.2 volts per cell.

16. Plug fuses have a maximum rating of 30 amperes.

17. A dry cell battery is an example of a PRIMARY cell.

18. Type "S" plug fuses shall not be INTERCHANGEABLE with plug fuses of different ampere classifications.

19. PRIMARY cells cannot be recharged.

20. A 600 volt cartridge fuse is permitted on a lower voltage.

21. A 12-volt lead-acid storage battery consists of 6 cells.

22. The maximum ampere rating of fuses rated 250 volts shall be 600 amperes.

23. Only DISTILLED water should be added to storage batteries.

24. Alkali-type battery is an example of a SECONDARY cell.

25. Plug fuses may be installed on circuits not exceeding 125 volts.

26. A storage battery is charged with DIRECT CURRENT.

27. A storage battery rated 6.000 amp. hours will produce 100 amperes for 3600 minutes.

28. Current limiting fuses shall not be INTERCHANGEABLE with standard fuses.

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
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TEST A-1
LESSON A-7 THRU A-12

1. The atom is electrically neutral because it consists of equal numbers of positive and negative charges. True/False ____________

2. Draw an arrow to connect the correct answers:

Electrons are	Electrically positive
Protons are	Electrically negative
Neutrons are	Electrically neutral

3. It is the motion of free electrons which makes up an electric circuit. True/False ________________

4. The atom is the smallest physical particle into which an element can be divided. True/False ________________

5. The molecule is a combination of two or more atoms. True/False.
____

6. True or False

   a. Copper is the best conductor. ____________
   b. Voltage is measured in units of volts. ____________
   c. The flow of electricity is due to the movement of electrons.
   ____
   d. An ammeter is connected parallel in a circuit. ____________
   e. A direct current always flows in the same direction, ____________
   f. A voltmeter is used to measure the resistance in a circuit.
   ____

7. a. An electric current is measured in ____________________.
   b. Give symbol for current. ______________

8. List four factors affecting resistance of a conductor.

   a. ____
   b. ____
   c. ____
   d. ____

9. Choose one.

   a. Conductors of ________________ resistivity are used for transmission lines and feeders. (a. Low b. High)
   b. Conductors of ________________ resistivity are used for incandescent lamps and toasters. (a. Low b. High)

NAME ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-1
LESSON A-7 THRU A-12

10. The two wire gages used in this country are:

a. ______________________________
b. ______________________________

11. Match Column B with Column A:

	A		B
____	A. The symbol for voltage	1.	Ohms
____	B. The instrument used to measure voltage	2.	Electrical pressure
		3.	Resistance
____	C. EMF	4.	Voltmeter
____	D. Resistance measured in	5.	E
____	E. Opposes current flow.	6.	Voltage ÷ Resistance
____	F. Current	7.	Resistance ÷ Voltage

12. A loose connection on conductors will (increase, decrease) the resistance.

13. Resistance (increases, decreases) with an increase in temperature.

14. Express Ohm's law for finding voltage. ____________________

15. Express Ohm's law for finding current. ____________________

16. Express Ohm's law for finding resistance. ____________________

17. If ten lamps of 100 watts each were burned for one hour, how much power would be used? ____________________

18. One horsepower equals ____________________ watts.

19. How could an electric motor have an efficiency of 100%? Explain.
____
____

20. A motor draws 3 amperes and operates at 250 volts. How much power is consumed? ______________ What is the horsepower rating of this motor? ______________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
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TEST A-2
LESSON A-13 THRU A-15

1. True or False

   a. In a series circuit, current remains the same throughout the circuit. __________
   b. In a series set of Christmas tree lights, if one lamp burns out, the other lamps will continue to burn. __________
   c. In a series circuit there is more than one path for current to flow. __________
   d. The total resistance is always smaller than the smallest resistor connected parallel in a parallel circuit. __________

2. List two disadvantages of series circuits:

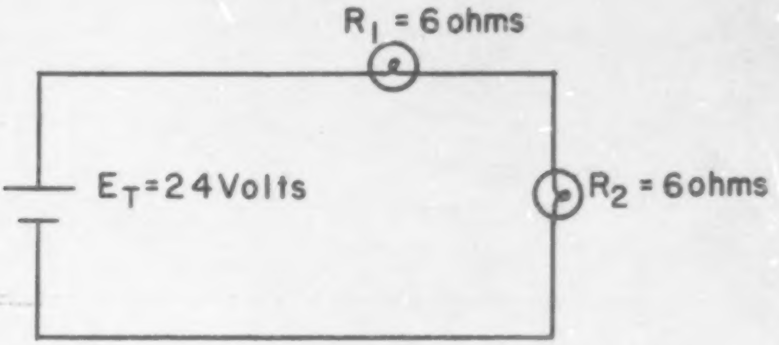
   a. ____
   b. ____

3. List two advantages of parallel circuits.

   a. ____

   ____
   b. ____

4. Solve for current:



NAME ________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
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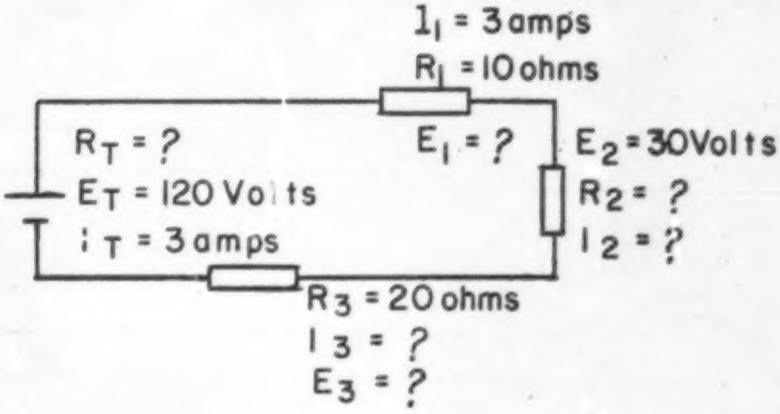
TEST A-2
LESSON A-13 THRU A-15

5. Solve for each unknown:


I_1 = 3 amps
R_1 = 10 ohms
R_T = ?
E_1 = ?
E_2 = 30 Volts
E_T = 120 Volts
R_2 = ?
I_T = 3 amps
I_2 = ?
R_3 = 20 ohms
I_3 = ?
E_3 = ?

R_T = ________________________

E_1 = ________________________

I_2 = ________________________

R_2 = ________________________

E_3 = ________________________

I_3 = ________________________

6. Describe the following symbols:

a. E_T ________________________

b. I_1 ________________________

c. R_4 ________________________

d. I_T ________________________

e. E_1 ________________________

f. E_4 ________________________

g. R_T ________________________

NAME ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
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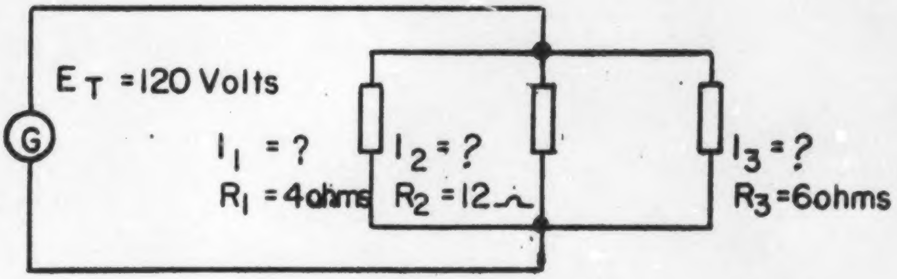
TEST A-2
Lesson A-13 THRU A-15

7. Write the two formulas for finding total resistance in parallel.

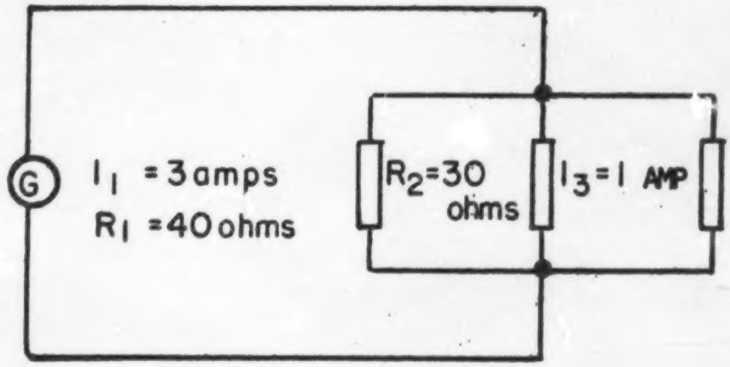
a.

b.

8. Find the total current and current in each branch of the following circuit:


G
E T =120 Volts
I1 = ?
R1 =4ohms
I2 = ?
R2 =12Ω
I3 = ?
R3=6ohms

9. Find the total voltage, total current and total resistance of the following circuit!


G
I1 =3amps
R1 =40ohms
R2=30 ohms
I3=1 AMP

NAME ______________________________

ELECTRICAL APPRENTICE
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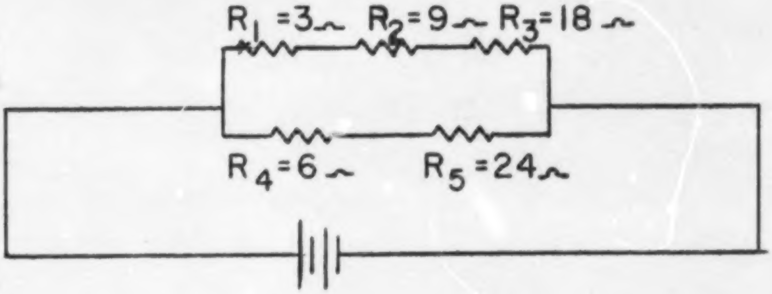
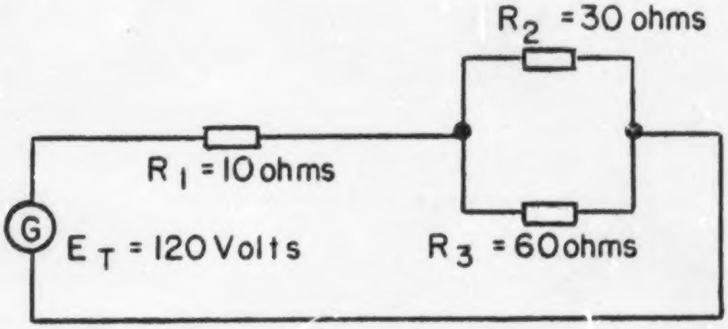
TEST A-2
LESSON A-13 THRU A-15

10. Find the total resistance of the following circuit.


R_1 =3 Ω
R_2=9 Ω
R_3=18 Ω
R_4=6 Ω
R_5=24 Ω

11. Solve for all values of current, resistance and voltage.


R_2 =30 ohms
R_1 =10 ohms
G
E_T = 120 Volts
R_3 = 60 ohms

NAME ____________________

DATE ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-3
LESSON A-16 THRU A-18

1. Copper is the most commonly used material for wires and cables due to its __________ resistance.

2. If aluminum wires are used, a _________ size wire may have to be used to carry the current necessary to serve the load.

3. A conductor is a wire or combination of wires, not __________ from each other, and suitable for carrying a _________ electric current.

4. A cable is a ____________ conductor or a _________ of two or more conductors laid together but ___________ from one another.

5. A good conductor has high/low resistance. ___________

6. Increasing the wire size raises/lowers the resistance if the same load is applied. ______________

7. Check the five factors used to determine the type of insulation a conductor must have.

   a. _____ Wet Locations
   b. _____ Dry Locations
   c. _____ Temperature
   d. _____ Length
   e. ______ Special Applications
   f. ______ Specific Locations
   g. ______ Altitude
   h. ______ Load to be carried

8. The longer the conductor, the greater/less the resistance.
   ____

9. Match the definition with the correct word it describes:

   a. Insulated
   b. Bare
   c. Covered
   d. Jacketed

   ____ Has a covering to protect from mechanical injury only
   ____ Has a covering to protect from hard service locations and exposure to moisture
   ____ Has no covering
   ____ Has a covering of material recognized as insulation

NAME ____________________

ELECTRICAL APPRENTICE
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TEST A-3
LESSON A-16 THRU A-18

10. Can a cable provide the following and still be encased in one jacket? Yes/No

1. Carry 6 volt sound pair conductors.
2. Carry 120 volt lighting circuit.
3. Carry 480 volt power circuit.
4. Carry a 240 volt DC power circuit.

11. If the answer to question #10 above is "yes", give the conditions which have to be met. If the answer is "no", give the reason it cannot be done. ____________________

____

____

____

12. The voltage drop of a 3 phase 4 wire circuit which is nearly balanced is about the same as a two wire single phase circuit. True/False ________

13. Why can the same ampere load be carried twice as far on a 277 volt circuit as on a 120 volt circuit? ____________________

____

____

14. Under most circumstances the resistance of an AC circuit is equal to a DC circuit when calculating voltage drop. True/False

15. Voltage drop in a circuit can be eliminated. True/False ________

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

1. The NEC contains ____________ provisions considered necessary for safety.

2. A general purpose branch circuit supplies outlets for ______ ______ and __________________.

3. In general, _____________ conductors are used to conduct current.

4. The minimum size conductor permitted for general interior wiring shall be No. _______ AWG.

5. A maximum of ______ fusible switches or circuit breakers may be used as service equipment.

6. A motor circuit switch is ________ rated and capable of ___________ under load.

7. The ___________ conductor is intentionally grounded.

8. ________________ plugs are not approved for securing equipment to masonry walls.

9. ________________ conductors, No.10 AWG and smaller, may be installed in a conduit.

10. Only Type _________ cable shall be installed for underground service entrance conductors.

11. A safety switch is an example of a ______________________ means.

12. Field applied insulation over the conductor splices shall be ____________ in value to the conductor insulation.

13. All _______________________ conductors shall be protected by an overcurrent device.

14. All holes in outlet boxes shall be __________________.

15. The NEC is not intended as a ________________ specification.

16. A _________________ is a circuit conductor between the switchboard and the branch circuit protective device.

NAME ________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

17. A minimum of ____________ inches of free conductor shall be provided at each outlet or switch.

18. The minimum mounting height of an overhead service drop is ________ feet above grade.

19. A multi-wire _________________ ___________________ consists of two or more undergrounded conductors having a potential difference between them and an identified grounded conductor waving an equal potential difference between it and each of the ungrounded conductors.

20. The NEC mandatory rules are characterized by the word ___________.

21. Electrical equipment mounted a minimum of __________ feet above the floor is a substitute for the required floor mounted horizontal clearance.

22. Equipment grounding conductors shall not be _____________________.

23. Lath shall not be used to support _______________ boxes.

24. The minimum size service entrance conductor is No. ________________ AWG.

25. __________________ switches have no interrupting rating and shall be operated only after the circuit is dead.

26. ________________ ___________________ conductors are located between the service drop and service equipment.

27. All conduits shall be ___________________ from outlet to outlet.

28. The maximum number of No. 10 AWG conductors permitted in a 1 1/2 inch x 4-inch square outlet box shall be ______________________.

29. The minimum size grounding conductor for three parallel 300 MCM service conductors shall be No. __________________AWG.

30. Neutral conductors shall not be ____________________________.

NAME ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

31. Outlet boxes in wood walls shall be set ______________ with finished surface.

32. Conductor ______________ or ______________ shall not be made within raceway.

33. A general purpose switch is rated in ______________ and capable of ______________ at its rated current and voltage.

34. ______________ locations are not normally subject to dampness or wetness.

35. The minimum size conductor permitted for multiple or parallel runs shall be No. ______________ AWG.

36. A vertical run of 350 MCM copper feeder shall be supported on a maximum ______ - foot center.

37. ______________ outlet boxes shall not be installed on a conduit system requiring locknuts and bushing.

38. A right angle pull junction box with entering and exiting conduits sized: 3-inch and 4-inch shall be a minimum of ______________ x ______________ inches.

39. A metallic ______________ ______________ piping system is the best grounding electrode.

40. Overhead service conductors shall form a ______________ loop at the service head.

41. Metal ______________ shall not be used to make grounding connection to water system.

42. Insulated bushings shall be installed on raceways for No. ______________ AWG and larger conductors.

43. Conductors of different systems may be installed in the same conduit provided all conductors are ______________ for the ______________ ______________ on any of the conductors.

NAME ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-4
LESSON A-19 THRU A-20

44. A lighting fixture exceeding _______ pounds shall not be supported from the lampholder screw-shell.

45. A straight pull junction box with a 3-inch conduit entering and exiting shall have a minimum length of _______ -inches.

46 The minimum size grounding conductor for service conductors shall be No. _______ AWG.

47. A lighting fixture exceeding _______ pounds shall be supported from the building structural members.

NAME ____________________

DATE ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-5
LESSON A-21 THRU A-24

1. Single conductor wiring is restricted to residential wiring only. True/False

2. The conductor separation for open wiring for voltage not exceeding 300 volts is __________ inches, and for voltage not exceeding 600 volts is ______ inches.

3. Conductor separation for concealed knob and tube work is the same as open wiring. True/False

4. Bare conductor feeders can be installed on bar joists or beams if a minimum clearance of 8 feet is allowed. True/False

5. Open and concealed knob and tube wiring and bare conductor feeders have the same ampacity rating as conductors installed in conduit. True/False

6. The code designations on non-metallic sheathed cable are:

   a. _________

   b. _________

7. The basic difference in the two cables listed above is

   ____.

8. Conductor sizes for non-metallic sheathed cable range from # ______ thru # ______ for copper conductors and # ______ thru # ______ for aluminum conductors.

9. The uninsulated or bare conductor is for ______________ purposes only.

10. The insulation of the individual conductors shall comply with the requirements for the type of conductors used. True/False

11. The code designations of service-entrance cable are (a) _________ (b) _________.

12. Can the uninsulated conductor of service entrance cable used as a branch circuit be used as the neutral. Yes/No

13. Underground feeder and branch circuit cable has the code designation of type __________.

NAME ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-5
LESSON A-21 THRU A-24

14. What is the minimum depth for cables buried directly in the earth? _______. Can this depth be reduced? Yes/No

15. Listed below are the Code type designations and descriptions. Draw a line to connect the correct type with its description.

ALS	Armored Cable
MI	Armored Cables with Lead Covered Conductors
ACT	Metal Clad Cable
MC	Mineral Insulated Cable
ACL	Armor Clad Cable with Thermoplastic Conductors
AC	Aluminum Sheathed Cable

16. The mineral insulation used in type MI cable is ______________________.

17. The individual conductors of multi-conductor type M. I. cable have no individual insulation. True/False

18. What are the four major insulating materials used for conductor insulation?

a. ______________________
b. ______________________
c. ______________________
d. ______________________

19. The support methods for metallic sheathed cables are the same as other cable assemblies. True/False

20. When flexible cord is used to serve an appliance or lamp the cord will be equipped with an attachment plug. True/False

21. Splices can be made in flexible cord. True/False

22. Tying a knot in the conductors of a flexible cord to keep strain off the terminal screws is prohibited by the Code. True/False

23. A flexible cord containing more than three (3) current-carrying conductors has to be de-rated. True/False

NAME ____________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-5
LESSON A-21 THRU A-24

24. In a five conductor flexible cord there are five different color conductors as listed below. Give the proper name for the intended use of each colored conductor:

a. Black ______________________________

b. Red ______________________________

c. Blue ______________________________

d. White ______________________________

e. Green ______________________________

25. All flexible cords have a grounding conductor. True/False

26. Fixture wires can be used as branch circuit conductors. True/False

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-6
LESSON A-25 THRU A-30

1. Rigid metal conduit shall be installed in a minimum of ________ feet below cinder fill.

2. E.M.T. shall not be installed on systems exceeding ________ volts.

3. The standard length of rigid metal conduit or EMT is ______ feet.

4. On exposed E.M.T. installations in wet locations, ______________ threadless couplings and connectors shall be used.

5. The number of bends and offsets in one run of conduit shall not exceed ________ degrees.

6. E.M.T. shall not be installed in a __________ fill.

7. Flexible metal conduit shall be supported on maximum ________ foot centers.

8. E.M.T. installed in concrete shall be provided with ______________ threadless couplings and connectors.

9. The maximum size conductor permitted in a 2-inch liquid-tight flexible conduit shall be No. ______ AWG.

10. All fittings for E.M.T. shall be the ____________________ type.

11. Outlet boxes used for interior wiring are classified into the following groups:

    a. ______________________
    b. ______________________
    c. ______________________
    d. ______________________

12. List the most important items which determine which type outlet or switch box must be used:

    a. ______________________
    b. ______________________
    c. ______________________
    d. ______________________

13. What determines the length of a straight thru junction box? Circle the right answer.

    a. Number of wires.
    b. Size of conduit.
    c. Number of conduits.
    d. Number of joints to be made in the box.

NAME ____________________

ELECTRICAL APPRENTICE
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TEST A-6
LESSON A-25 THRU A-30

14. What determines the length of an angle or u-pull junction box? Circle the right answers.

   a. Number of wires
   b. Size of conduit
   c. Number of conduits
   d. Number of joints to be made in the box

15. Boxes over 100 cubic inches in size are classified as a __________ or ______________ ______________ box.

16. What is the main difference between an auxiliary gutter and a wireway? ____
____

17. Can splices and taps be made in auxiliary gutters and wireways? Yes/No. If the answer is 'yes' under what conditions may they be made. ____
____

18. The Code limits the number of current carrying conductors to 30 in both auxiliary gutters and wireways. True/False

19. Does Note #8 to Tables 310-16 through 310-17 apply to auxiliary gutters and wireways? Yes/No.

20. Does a 20% fill capacity limit apply to auxiliary gutters and wireways? Yes/No.

21. If the answer to the above question is 'yes' or 'no' circle the one to which the 20% fill is applicable.

   a. Auxiliary Gutter   b. Wireway   c. Both

22. Can un-used knock-outs be left open in the bottom of a cabinet or cut-out box for ventilation? Yes/No. Give the Code section and p paragraph rule for your answer. ______________

23. A single 500 MCM conductor per phase is loop fed thru one panel with double barrell lugs to another panel. What is the minimum width gutter allowed? ________________

24. Name six (6) methods by which extensions can be made from a wireway to other items of electrical equipment.

   a. ______________________   c. ______________________
   b. ______________________   d. ______________________
   e. ______________________
   f. ______________________

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-7
LESSON A-31 THRU A-36

1. Match the correct word or number with the statement which best describes it:

   a. Visual Comfort
   b. Brightness
   c. Glare
   d. 186,000 Miles Second
   e. Foot Candles
   f. Light Bulb

   ______ 1. The speed of light.
   ______ 2. Light "out of place" causing eye discomfort or interference with vision
   ______ 3. The unit of illumination or light density equal to one lumen per square foot,
   ______ 4. An expression related to the degree of brilliancy of any surface omitting or reflecting light.
   ______ 5. Freedom from direct or reflected glare.
   ______ 6. A device for converting electrical energy into visible radiant energy.

2. Rate the three basic light sources as to their efficiency in lumen per watt output: (1st, 2nd, 3rd)

   1 2 3 Fluorescent

   1 2 3 Incandescent

   1 2 3 High Intensity Discharge

3. High intensity discharge lamps can be separated into the following major categories:

   a. ______________________
   b. ______________________
   c. ______________________

4. All lamps have similar component parts. List below the five (5) most common parts of a lamp.

   a. __________________ d. ______________________
   b. __________________ e. ______________________
   c. __________________

NAME ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FIRST YEAR - SERIES A
TEST A-7
LESSON A-31 THRU A-36

5. What is a Class "P" ballast? ____________________

____

____

____

6. The five principal methods of fluorescent lamp operation are:

a. ____________ d. ____________
b. ____________ e. ____________
c. ____________

7. What are the four classifications of high-intensity discharge lamps?

a. ____________ c. ____________
b. ____________ d. ____________

8. What is the basic difference in the three major types of high-intensity-discharge lamps?

a. Shape
b. Lumen output
c. Vaporizing metal used
d. Mounting position

9. What percent overload is a fuse capable of carrying before blowing?

a. 10%
b. 25%
c. 45%
d. 125%

10. Match the following letter to correspond with the matching number?

_____ 1. Plug fuse	a.	maximum rating 6000 ampere
_____ 2. Cartridge fuse at 250 volts	b.	maximum rating 30 ampere
_____ 3. Silver sand	c.	maximum rating 600 ampere

11. Dual element cartridge fuses contain a thermal element and a fuse link. True/False. __________

12. Temperature will affect the operation of thermally controlled circuit breakers and must be considered in the application and sizing. True/False. __________

NAME ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
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TEST A-7
LESSON A-31 THRU A-36

13. Lead-acid type batteries are rated _____ volts per cell.

14. Fuses are rated in _________ and _________, and have a ________ resistance.

15. Alkali-type batteries are rated _______ volts per cell.

16. Plug fuses have a maximum rating of _____ amperes.

17. A dry cell battery is an example of a ____________ cell.

18. Type "S" plug fuses shall not be ______________________ with plug fuses of different ampere classifications.

19. _____________cells cannot be recharged.

20. A ____________ volt cartridge fuse is permitted on a lower voltage.

21. A 12-volt lead-acid storage battery consists of ______ cells.

22. The maximum ampere rating of fuses rated 250 volts shall be ________ amperes.

23. Only ______________ water should be added to storage batteries.

24. Alkali-type battery is an example of a ______________ cell.

25. Plug fuses may be installed on circuits not exceeding ___________ volts.

26. A storage battery is charged with ________ __________.

27. A storage battery rated 6.000 amp. hours will produce 100 amperes for _________ minutes.

28. Current limiting fuses shall not be _______________ with standard fuses.